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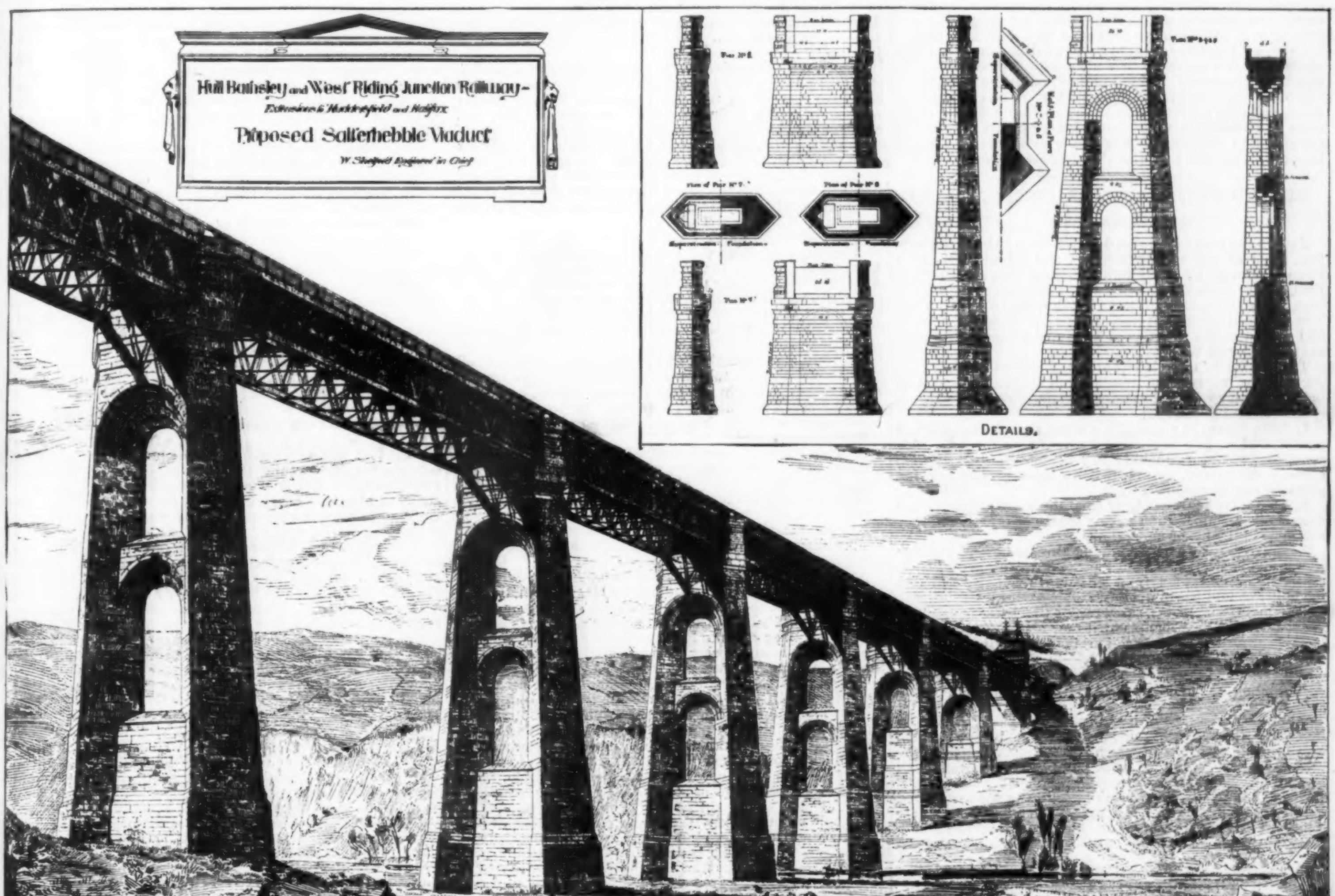
SALTERHEBBLE VIADUCT.

We publish a perspective drawing of the viaduct over the Salterhebble Valley, which will form a portion of the proposed Huddersfield and Halifax extension of the Hull, Barnsley, and West Riding Junction Railway, for which Mr. W. Shelford, M.I.C.E., of Westminster, is engineer-in-chief. The site of this viaduct is about a mile south of the busy manufacturing town of Halifax, where the proposed extension terminates. It is intended to construct the whole of the piers and abutments of this important work of masonry, as the neighborhood abounds in some of the best of the Yorkshire building stones. It may be remarked that, owing to the various spans required by Parliament for crossing the very stable and lasting structure. As the solid rock lies but a few feet below the surface of the ground in the vicinity of the viaduct, no difficulty need be anticipated with regard to the foundations for the piers and abutments. The ironwork of the viaduct, which shows very clearly in the perspective view, has been well designed. The main girders are of the simple Warren type, 126 ft. span between center of bearings, and placed 23 ft. 8 in. apart between centers, so arranged to allow the doors of the carriages of passing trains to open over them, and thus effect considerable economy in width over the usual custom of carrying the rails so that trains pass directly between the main girders. This method also affords greater security, as in the case of a train leaving the metals, it could not endanger the structure by striking half, and of those for December three-fourths, occurred to passenger trains.

The *length of time* intervening between the misplacing of a switch (or the time when it ought to have been set right) and the time an accident occurs is a point which, if it could be illuminated, would doubtless afford some valuable light on this subject, but unfortunately there are no data on it. However, it is probably safe to say that the interval is comparatively long; that is to say, that when a train encounters an "open switch" the likelihood is that it has been "open" for a considerable period. If this is so, it gives additional force to the argument for the necessity of periodical inspection by some person other than the switchman who is actively engaged in the moving of the switches.



VIADUCT.—HULL BARNSLEY AND WEST RIDING JUNCTION RAILWAY

roads, railways, and canals which lie in the valley, the introduction of girders as a means of carrying the railway over these necessarily large openings became the most feasible method of meeting all requirements, and in consequence of this a viaduct built entirely of stone was out of the question. It will be seen, on reference to our illustration, which is reproduced from a pen-and-ink drawing by Mr. Leonard Stokes, that the piers are of a massive character, and in rather bold and novel lines, and their form is not only calculated to produce a fine effect, but is also well adapted to the sharp skews of the roadways required. Our first perspective will afford a good idea of the effect which will be produced by the viaduct, when viewed from the southern side of the valley, combining as it does architectural effect with the necessary stability and engineering requirements, which, we regret to say, is not usually the case in large structures of this kind. The total length of the viaduct, when completed, will be 1,342 ft., consisting of a southern abutment, having a 40 ft. arch spanning a road, nine spans of 130 ft. each between centers, and a northern abutment with a plate girder bridge of ordinary construction over another road. The greatest height from the surface of the ground to the level of the rails is 142 ft. The viaduct runs nearly due north and south. Our perspective, taken with the details, will enable our readers to readily grasp the general arrangement of the piers, which are well calculated to produce a against the lattice bars and struts, but would be guided safely along by the top booms of the main girders, until brought to rest. To reduce as much as possible the likelihood of a train leaving the rails in a gale, a wind fence is provided which effectually screens the carriages from the full force of the wind.—*The Building News.*

A SWITCH INSPECTION MONITOR.

Derailments and collisions resulting from misplaced switches seem to constitute one of the most *permanent* sources from which our monthly accident record draws its supply of "specimens," if not the most prominent, as compared with accidents of other kinds which are usually attended with more exciting circumstances. Every month is sure to show a number of this kind, and, though the casualties are perhaps not numerous as compared with the number resulting from other kinds of accidents, the list seems to be always inviting investigation, from the fact that the *causes* are generally so apparently simple, and, one might suppose, easily remedied by reason of this simplicity. The thousands of accidents which never reach the newspapers because of their comparative insignificance doubtless include a large number of the kind named, and a large proportion of the whole probably concern freight trains only; and yet, of those recorded for November, more than one-

It is doubtless true that both the proximate and the remote causes of the negligence which results in these accidents have their origin in a great variety of circumstances, this view finding special favor with the persons who commit the blunders, and who desire to furnish themselves with some plausible and logical explanation of a phenomenon that is quite likely unexplainable except on the general ground of "total depravity," and it is consequently often thought that the remedy must be equally many sided in order to touch the difficulty. We are inclined to think, however, that the one word "discipline" pretty nearly covers the case. Where our evils start from such a variety of sources that we cannot prevent them, often the next best thing is to station a double force of headsmen and slay them as they make their final attack, it being just as efficacious to kill them then as in their incipiency, provided only that the extinction is certain.

For facing-point switches unprovided with inter-locking signals, as thousands must remain for years to come, the best *theory* of protection is, undoubtedly, to provide a switchman to look after the switch and another man to look after the switchman; and this is, in fact, generally the object sought in issuing the usual order that station agents must examine switches a certain number of minutes before the arrival of each train. But not only in the cases where there is only one man at a station, who must, consequently, be

his own monitor, but in others as well, this plan fails of effectual execution for the reason that the duty of watching a switchman—or any one else—whose lapses occur only one time out of ten thousand is an exceedingly monotonous and uninteresting one. If the person whose conduct we are watching requires frequent or even occasional correction or advice, our task has in it some degree of interest, and we are stimulated to renewed vigilance on every occasion which calls special attention to the subject; but after looking at a switch several times a day for a long period and finding it always right, the sense of danger is quite likely to be weakened, and the continued carefulness of the switchman induces the monitor unconsciously to lay a part of his own responsibility upon him.

Where a person is disposed to shirk, it would perhaps be hard to find a remedy for this difficulty; but for station agents or others who honestly intend to keep a regular watch upon their switches, but find it hard to keep their vigilance up to the sticking point, an excellent mechanical aid is an alarm clock, set to give warning of the hours at which the duty should be attended to.

Mr. B. B. Adams, Jr., station agent of the Boston & Albany road at Westfield, Mass., has in use a novel arrangement of this kind which could be profitably copied in a good many yards. For his office time-piece he has one of J. A. Lakin's "programme clocks," which are arranged to *strike* at intervals of five minutes all day, or to *omit* any one or all of them, as desired, the effect being to provide a warning for any number of irregular occasions during the day. For trains due say at 9:30, 10:15, 10:40, 1:05, and 4:10 the clock can be set to strike at 9:20, 10:05, 10:30, 12:55, and 4:00, and at no other time, thus providing an unerring reminder to the agent or clerk in the office to make each required examination of switches at exactly the right time.

Mr. Lakin also furnishes these clocks with electric circuit closers, so that they can be arranged to warn not only the occupan of the office but also any desired number of switchmen, gate-tenders, or others, by means of a battery wire, and electric bell. Whenever a change in the time-table makes it necessary to set the clock to strike at different hours, the alterations can be made in a moment. This arrangement may be the means of making safety doubly sure in thousands of instances where it now depends upon one unaided mind, and thus prevent some of the accidents which result from the tenacious way in which employes of various grades hold to the view that to make safety singly sure, so to speak, is all that is required.—*Railroad Gazette.*

ZINC TO PREVENT BOILER INCRUSTATION.*

By G. SWINBURNKING.

AMONG the many inquiries directed upon the general subject, some of the most exhaustive and minute have been those instituted by the Admiralty, extending from 1874 to 1880. They were carried out by committees appointed to inquire into the causes of decay in the boilers of H.M. ships. The committees were invested with very abundant powers, and were directed to propose measures tending to increase the durability of boilers.

The results of their labors are contained in very able reports, full of valuable information and practical suggestion; but for the purpose of the present inquiry, they may be briefly summarized as follows:

1. With regard to a prevailing belief that the presence of particles of copper in a boiler was a source of injury, they state, first, that the quantity carried into the boiler is extremely small; and, second, that no injurious effect of importance can be produced by it.

2. That fatty acids resulting from the use of vegetable and animal oils for lubrication were a source of injury, and they recommend the use of mineral oils.

3. Moist air, or water containing air, are powerful corrosive agents. They recommend increased density in the water, especially in boilers fed from surface condensers, and that the boiler should be emptied as seldom as possible.

The main conclusion, however, at which the committee arrived—the great principle that they asserted and demonstrated—was that galvanic action, induced by the contact of zinc with the iron of the boiler, was the best and only trustworthy remedy for corrosion; and that, so long as the metallic contact was maintained, little or no corrosion would go on.

They adopted a plan of hanging slabs or plates of zinc by iron straps from the stays or rods within the boiler, the zinc being held in a clip in which it was tightly bolted. The theory was perfect, but the weak point in practice was found to be in keeping up electric contact between the two metals. The zinc and the iron not being metallically connected, but only mechanically pressed together, were liable to be so far separated—by the corroding of the surface of the zinc—that the galvanic current was soon weakened and destroyed.

The committee endeavored to circumvent this difficulty, first, by fixing in each boiler an excessive number of plates, so that (apparently) if electric contact should cease even in many plates, it might chance to be maintained in some; and, secondly, they directed a frequent examination with the view of renewing the contact, and putting in fresh plates in lieu of those destroyed by corrosion.

This system was the best they were able to arrive at, but it could be maintained only at such a cost that, to use the words of the report: "The expense of the zinc necessary for efficient protection is undoubtedly an important element in determining how far it should be adopted." For besides the expense of fitting, examining, and renewing the excessive number of plates already referred to, the committee go on to say that "the actual waste of zinc is much greater than that due to the protection of the boiler; and it becomes important to ascertain whether that waste cannot be avoided."

With great care, however, this system was found to prevail against the inroads of corrosion; and herein was a distinct advance, although it still left the question of incrustation by lime-scale comparatively untouched. Indeed, it is stated that the scale which formed in some of the boilers in which slabs or plates were used became "harder and more adherent," and it was therefore suggested that the zinc should be periodically removed altogether, for a limited time, in order that a slight corrosion forming under the scale might enable it to be separated more readily from the iron.

Under the Admiralty system, then, it must be presumed that the bad effects arising from scale, such as the burning of the iron, the waste of coal, and the injury caused by severe chipping, are still a source of trouble and expense; and such I believe is the case. I have before me a specimen of the scale which formed in two months in one of H.M. steam vessels. It was recently taken from a boiler treated on the Admiralty method, and considered to be in very good order.

The committee's report attributed this hard scale to the action of the excessive quantity of zinc which was found necessary for protection when used in the form of slabs or plates. This, however, is now shown to have been an erroneous conclusion, the real cause being that the galvanic current set up under the Admiralty system has not sufficient intensity. I hope to explain this point a little more fully later on.

Now, having pointed out where the Admiralty method fails, I must give credit to the inventor, *per contra*, for the large amount of success it has, nevertheless, achieved. Experience teaches us that few inventions cannot be improved upon, and Mr. Weston himself, of whom I am about to speak, would be the last to claim perfection for his particular plan of protecting boilers by means of zinc.

Mr. William Weston is the Admiralty chemist at Portsmouth, and was a member of the Boiler Committee, whose collective labors are worthy of all praise. It is due to him, however, to state that the system of protection finally adopted in the British navy was initiated and worked out by him, with indefatigable pains and assiduity; and that his method, whatever may be its shortcomings when viewed in the light of later discovery, has worked so well that near half a million of money must have been saved to the navy and the British tax-payer since its introduction.

Before the application of the galvanic principle, it was not an uncommon occurrence for the boilers of H.M. ships to be worn out in one commission, or, at least, to become so unsafe as to render their renewal necessary; and, as a case in point, I may mention the Bellerophon, whose boilers had to be renewed, after serving only one commission of three or four years, at a cost of some £30,000.

A man who serves the Queen is content to do his duty, and must often do so without being singled out for praise or reward even for special services; but in this paper I am at liberty to mention the name of Mr. Weston with honor, and to claim for him the personal credit which is his just due.

The mercantile marine has in a great measure followed in the wake of the navy; and zinc is now very largely employed in the fleets of all the large companies. Every possible method of fixing it in the boilers has been adopted, with more or less success. Engineers who understood the principle of its action in forming with the iron a galvanic battery have sought to secure metallic connection by many mechanical device; while others, convinced of its efficacy, but not understanding its methods, have even thrown it loose into the boilers, to waste and crumble away to no purpose.

Zinc, indeed, had long been used with the object of depositing any minute particles of copper that might find their way into the boiler. It was useless for this purpose, as the Admiralty inquiry fully proved; but wherever it happened to be connected with the iron, it became protective, by setting up electric action, which would continue for a short time, until oxidation of the zinc had broken the electric contact.

A superintendent engineer who was using zinc in his boilers, fixed to the iron, told me he did not believe in the galvanic theory, while in practice he was profiting by it; and when I pointed out this fact, and asked him to explain on what other principle the zinc could be protective, he was unable to answer me.

Another engineer to an important company told me he had a theory of his own, that what was called corrosion and pitting was nothing of the kind, but was solely the result of friction from the circulation of water in the boiler. On the other hand, the majority of superintendent engineers, who have some knowledge of electricity and chemistry, are quick to appreciate the truth of the now ascertained cause, and the scientific remedy.

Among the numerous methods adopted for fixing the plates in boilers, the plan patented by Mr. Phillips (formerly a member of the Admiralty Committee) was considered one of the best. It consists in attaching a plate of zinc to a stud or peg, 3 or 4 inches long, projecting from the shell of the boiler, the plate being screwed on tightly by a nut, to insure close contact with the iron. This system, however, is liable to failure, like all other modes of mere mechanical attachment, as I shall be able to show; and the only means whereby it can be made at all successful is by introducing an excessive number of plates, at great expense, and by constantly examining, cleaning, and renewing them. I have known as many as thirty-eight plates fixed in each of six boilers in one ship on this system, and as many as fifty-six in one boiler of a ship of war on the Admiralty system.

Now, it often happens that when one mind is moved to investigate in a particular direction, another, at a distance, is working to the same end; and men unknown to each other are working out the same problem, and arriving at similar conclusions. So it was in the application of zinc to steam boilers. While Mr. Weston was working up, step by step, to his present system, Mr. Hannay, of Glasgow, an electrician and chemist, alone in his laboratory, or watching experiments in steam factory or sea-going ships, was building up fact upon fact, and coming about the same time to the same conclusion in principle. In the application of that principle he made an important advance on other methods.

I will endeavor, as briefly as possible, to narrate his proceedings, and describe his invention. The investigation was commenced for the Allan line of steamers, from Glasgow, at the request of Messrs Allan Brothers, who, like all owners of steam power, were deeply interested in the boiler question.

The common theory held at that time was that free oxygen and carbonic acid in the water were the active causes of corrosion, and Mr. Hannay's first experiments were directed to absorb the oxygen by the ordinary methods known to chemists, with the result, however, that corrosion continued. When an alkali was added to absorb the carbonic acid, priming was caused to such an extent as to be dangerous to the safety of the machinery. He may be said to have exhausted chemistry in his endeavor to find a means of stopping the decay; but, although he succeeded in removing every trace of free oxygen and carbonic acid, the corrosion still continued after six months of patient trial. He concluded therefore, that, while free oxygen and carbonic acid might help to corrode the boilers, they were certainly not the chief causes.

It next occurred to him that certain parts of the boiler more highly heated might, for reasons familiar to science, have their surfaces so altered as to cause them to become electro-negative to the colder parts. This view was particularly impressed upon him from the fact that corrosion so often took place along certain well defined lines, as, for instance, along the sides of the fire tube. Sometimes the corrosion was so deep that there was reason to apprehend collapse of the furnace. The cold blast going to feed the fire kept the part where the corrosion was quite cool, while the flames kept the top very hot.

Starting, then, from these facts, he deduced the theory that thermo-electric currents were set up between the colder and hotter parts of the boiler, and that the colder part, forming the positive pole, corroded by the natural law of galvanic action.

To test this theory, experiments were made with a boiler specially constructed to allow it to be heated in sections, and to stand a pressure of 200 lb. to the square inch. Two iron plates were fixed in the boiler, one near the top and the other near the bottom, and both were connected with a galvanometer, so that a current of electricity passing from one plate to the other could be detected and measured. The boiler was heated alternately more strongly at the top or the bottom, with the constant result that whenever the temperature rose above the point, as in a steam boiler, the cooler plate became positive, and wasted away. Thus the theory was lifted into the region of ascertained fact.

Attempts were made to keep boilers in actual use more uniformly heated, but if corrosion were stopped in some places, it was sure to break out in others.

It appeared, therefore, that the only way to prevent this corrosion was by making the iron all negative by a current stronger than that set up in the iron itself by differences in temperature. The current was estimated, and found to be very small; a weak battery was fitted up, and the positive electrode, or wire, passed into the water of the boiler, the negative electrode being soldered to the outside of the boiler.

After six months' trial with this arrangement, it was found that corrosion had entirely ceased.

Two important facts, therefore, were now made clear: natural electric currents, so to speak, caused corrosion, and a stronger artificial current could be made to cure it.

The experimental boiler was then again tried with the same arrangement as before, but it was first filled with dilute acid. The current was kept going for three months, when it was found that the interior of the boiler was still quite free from corrosion, the acid having been powerless to injure it.

The actual natural current between the metals being so very small, it was thought that, instead of a battery, a simple galvanic couple, formed by a mass of zinc within the boiler, properly connected with the iron, might be sufficient to overcome it.

Now, the theory of zinc in contact with iron preventing corrosion may be illustrated thus:

Take two pieces of metal, one of zinc and one of iron, and immerse them in a solution of water diluted with acid; both will suffer from corrosion; but connect them with a wire, and you make them at once into a galvanic couple. A current of electricity is set up between them—the corrosion is directed entirely upon the zinc, which crumbles away, while the iron is no longer injured. The zinc is the positive, and the iron the negative pole. Now you have only to continue the plate of iron till it extends all round the zinc and incloses it, and you have a perfect illustration of the manner in which an iron boiler inclosing a block or mass of zinc is made as a whole into the negative pole of a galvanic couple, and is thenceforward absolutely protected from corrosion. It will also become evident that if the connecting wire be broken, or the contact between the zinc and the iron made imperfect by the intervention of any foreign matter, the galvanic current will cease, and the iron of the boiler will corrode as well as the zinc—just as the two pieces of metal were seen to corrode before they were joined by a wire.

The theory, then, of the protection of iron by contact with a more electro-positive metal being unassailable, and experiment corroborating it, inquiry was next instituted to discover the cause of failure in zinc as ordinarily employed.

It was found that, as zinc had been previously used, no proper arrangements were made for insuring a true and lasting metallic contact. To show how this fact was demonstrated, and at what pains it was ascertained, a narration of one of the numerous experiments made will be interesting: A boiler was fitted with rolled zinc plates attached to studs, on Mr. Phillips' principle, as previously described. Every precaution was used to give perfect metallic contact. The stud was filed bright and made slightly conical, the hole in the zinc plate made to fit tightly, and the nut on the stud screwed home, so as to drive the plate into thorough contact with the clean iron. An insulated wire was fixed to the plate, and led through a stuffing box packed with India-rubber. Another wire was soldered to the outside of the stud. When a small battery and a galvanometer were put in circuit, the current passed from the zinc to the stud, and so round again to the battery, proving that the contact was perfect. There were six plates put in on trial altogether, and the result was that, after three days' boiling, two of the plates had become metallically disconnected from the boiler—that is to say, no current could pass through the circuit. After five days, another plate became useless, owing to the same cause. At the end of twelve days, only one plate was in electrical contact with the boiler. The boiler was opened after thirteen days' steaming, and it was found that none of the plates were really used up, but that a layer of oxide of zinc had formed between the plate and the stud, and the zinc was thus rendered useless. It must be remembered that these six plates were all specially fitted, and ought to have acted thoroughly well if anything could. The sixth plate was sent away with the ship again, but only remained active two days. It was eaten through when the boiler was again opened.

By this and other experiments it was proved that no mere mechanical attachment of the zinc will suffice to insure continued maintenance of the galvanic current, because, no matter how closely the zinc is fitted to the stud, or bolted to the iron, the water creeps in between, and soon destroys the metallic contact.

It was also found that the use of plates was faulty. If they are cast, they spilt up and fall to pieces in a few days; and if rolled, they are only about a quarter of an inch in thickness, and they soon dissolve away.

To meet the various defects in the use of zinc plates, Mr. Hannay designed a ball of zinc, with a copper conductor cast through the center of it, the copper being so combined and amalgamated with the zinc at the junction of the two metals as to form brass, and thus no corrosion could form between them to stop the galvanic current. The zinc is well hammered at a certain temperature, insuring long existence in an efficient condition.

This ball of zinc is called an "electrogen;" it is fitted in any convenient part of the boiler by a simple device, and a wire from each end of the copper conductor is soldered firm

* From a recent paper read before the Society of Arts, London.

ly to the iron. From this moment the electrogen keeps up an uninterrupted galvanic current, and the whole of the interior of the boiler is absolutely protected from corrosion so long as any of the zinc remains.

It was ascertained, by further experiments, that a very small surface of zinc was sufficient to afford protection for a radius of twenty-five feet from the point of contact, and the spherical form of the zinc was adopted because it would maintain perfect protection with a minimum of waste, the large surface exposed by plates in proportion to their bulk being quite unnecessary. Herein, therefore, was the means of avoiding that waste which Admiralty Committee stated was "much greater than that due to the protection of the boiler," and for which they sought a remedy.

Two electrogens are found in practice sufficient to protect an ordinary "single ended" marine boiler in which, by some engineers, forty or fifty plates would have been considered necessary. The electrogens will last for about six months, while the plates would probably corrode away in as many weeks.

The advantages that Mr. Hannay claims for his system, as compared with any employment of zinc plates, are that it is less expensive and more effectual, and that the protection it affords does not depend upon a chance contact that may be destroyed at any moment. But a further gain, perhaps even greater than these, is that it does not allow scale to form in a boiler at any time to a much greater thickness than that of an egg shell, or a coat of paint.

The zinc ball with its perfect contact generates a current of greater intensity than zinc plates mechanically fitted, and the consequence is that a portion of the water is slowly decomposed, and the hydrogen that is evolved at the negative pole, all over the surface of the iron and underneath the scale, forces off the scale in thin flakes by mechanical action, as soon as it becomes thick enough to be impervious to the hydrogen. In this way the scale is kept forming and reforming, hanging in loose flakes or falling off as it becomes detached from the iron

Thus all the evils attending incrustation, which have been before enumerated, are avoided. Fuel is saved, burning of the iron is prevented, and chipping becomes no longer necessary.

The reason why scale becomes more hard and coherent under the zinc-plate method as used in the navy, is that while the galvanic current set up acts in retarding corrosion, it has not sufficient intensity to decompose the water and deposit a layer of hydrogen on the iron; so the scale grows on a firm surface, and is not pushed off by gas evolved beneath it.

When zinc is merely pressed against iron, the two metals really touch each other at minute points only, and thus great resistance is introduced. Resistance in this case means that the current is destroyed to a certain extent as electricity, and converted into heat, just as the resistance of the brake destroys the motion of a train and converts it into heat. Then the water creeping in between the two metals, and forming a non conducting oxide between the two surfaces, increases the resistance, and ultimately prevents the passage of the current altogether.

When resistance is prevented, and the full intensity of the current is allowed to pass from the zinc to the iron, and back through the water, hydrogen is slowly accumulated at the iron surface, yielding protection from corrosion, and, at the same time, loosening and throwing off the scale.

The value of any discovery that will prevent the formation of hard scale in land-boilers can scarcely be overrated. Those boilers in which fresh water is used do not suffer so much from internal corrosion; but the calcareous scale, which forms in them, has been always a great source of trouble. Compositions have failed, and zinc plates are ineffectual to remove it.

The electrogen, however, seems to have solved the problem; and to make it sufficiently active in fresh water, the homœopathic principle is applied of *similia similibus curantur*. A small quantity of salt, which is the active corrosive agent in sea water, is made, not only to cure the disease of corrosion which it actuates, but to stimulate an electric current which entirely disposes of incrustation.

Sea water contains on an average 32 to 38 parts of salt in 1,000. Mr. Hannay's homœopathic dose is half an ounce to a gallon, or four parts to 1,000; and as no proportion less than eight times this amount has any effect on iron, no harm can be done to the boiler, even if it were not protected by the zinc. Into brewers' "tanks" and other boilers, the water from which is used for manufacturing purposes, salt, of course, cannot be admitted; but this difficulty is overcome by a simple device, by which the salt is kept separate from the body of the water.

Land-boilers, in many districts, would become quite unworkable through the accumulation of scale, if it were not chipped off every five, six, or eight weeks—of course at considerable expense—the boiler lying idle during the process. With electrogens it has been proved that boilers will work more than twice the usual time without any necessity for opening them, and that then the loose flakes of scale may be cleared out in a short time with a hose and a broom. Meantime, no thick scale being allowed to form, it becomes perfectly harmless; the coal consumed does its full work, and steam is made more freely.

Engineers, who have witnessed the results in several recent trials, have stated their opinion that the discovery will revolutionize the treatment of land-boilers.

In conclusion, a further and valuable addition has been made to the marvelous applications of electricity, which have pre-eminently distinguished the last decade of scientific discovery.

But there is no finality in human invention. More light will dawn, and with it new marvels will arise. It may be that before another decade has run its course, electricity or atmospheric power will have superseded steam, and the huge iron boiler of to-day will be looked upon as the clumsy expedient of an ignorant generation.

Till then, while the evils we have been considering exist, and are potent for the destruction of life and property, inquiry into their nature and origin is both desirable and necessary, and time will not have been wasted in seeking to discover the most effectual remedies.

IMPROVED HYDRAULIC PUMP.

M. ALBERT MARNIER has described in a recent issue of the *Revue Industrielle* a hydraulic pump, designed by M. C. Roux, an engineer at the works of MM. Schneider & Co., and built by MM. Crozet & Co., for the Saint Pierre pit, belonging to the Creusot Company. Our illustrations this week show the construction of this pump, the principal and novel feature of which is the valve motion. The complete machine consists of two double acting pumps, each of which is provided with two horizontal bronze plungers, G_1 G_1, separated by a larger piston, G, Fig. 1. A large valve, F allows the water to flow alternately behind either end of the piston, G, and a smaller piston valve, E, which regulates the movements of the valve, F. The water to be pumped enters through the suction pipe, A, flows through the suction and discharge valves, H and J, and is discharged through C. In the position shown in Fig. 1, the valves, E and F, have just completed their backward movement, and have cut off the communication through the channel shown in dotted lines between the pressure water and the right end of the piston, G. At this moment the power water filling the channel, *a*, passes through the small openings in the cylinder of the distributing valve, E, flowing through *b* and *c* into *d*, and passing through *e* and *f*, before the driving piston, G. The piston then moves backward, forcing the water out before it through *g h j k*. Just before reaching the end of its stroke, the piston, G, uncovers the small orifice, *l*, and the water rises through *l m* to a point behind the valve, E. The pressure causes the latter to move toward a position at the other end, and at the same time the communication between the piston, E and F, is through the chamber, *r*, re-established, and the pressure water forces the piston, F, to another position. No counter pressure disturbs the free movement of the valves, because, as soon as the piston, G, has passed one of the orifices, *l* or *n*, the water in *m* or *p* flows off. The same is true of the valve, F, one of the ends of which is always alternately open. The pump, therefore, works without any tappets, its moving parts are out of the reach of dust, and it may be drowned without effecting its motion.

The Saint Pierre pit of the Creusot Company, in which it is at work, is 267 meters deep. Into it from 1,920 to 3,000 meters of water flow, which drop 85 meters into the sump of the great Saint Laurent pumping engine, so that the latter, therefore, has a lift of 85+267, or 352 meters. This head of 85 meters is utilized to force a part of the water to a height of 352 meters, and to that extent relieve the Saint Laurent pump. It was assumed at the start that under these conditions it would be possible to lift one-tenth of the water, and the useful effect, therefore, looked forward to was 41·4 per cent. It is now working very satisfactorily, and is started easily. M. Marnier states that MM. Crozet & Co. propose to use the same principle in designing water meters and steam pumps.

THE ROUX HYDRAULIC PUMP.

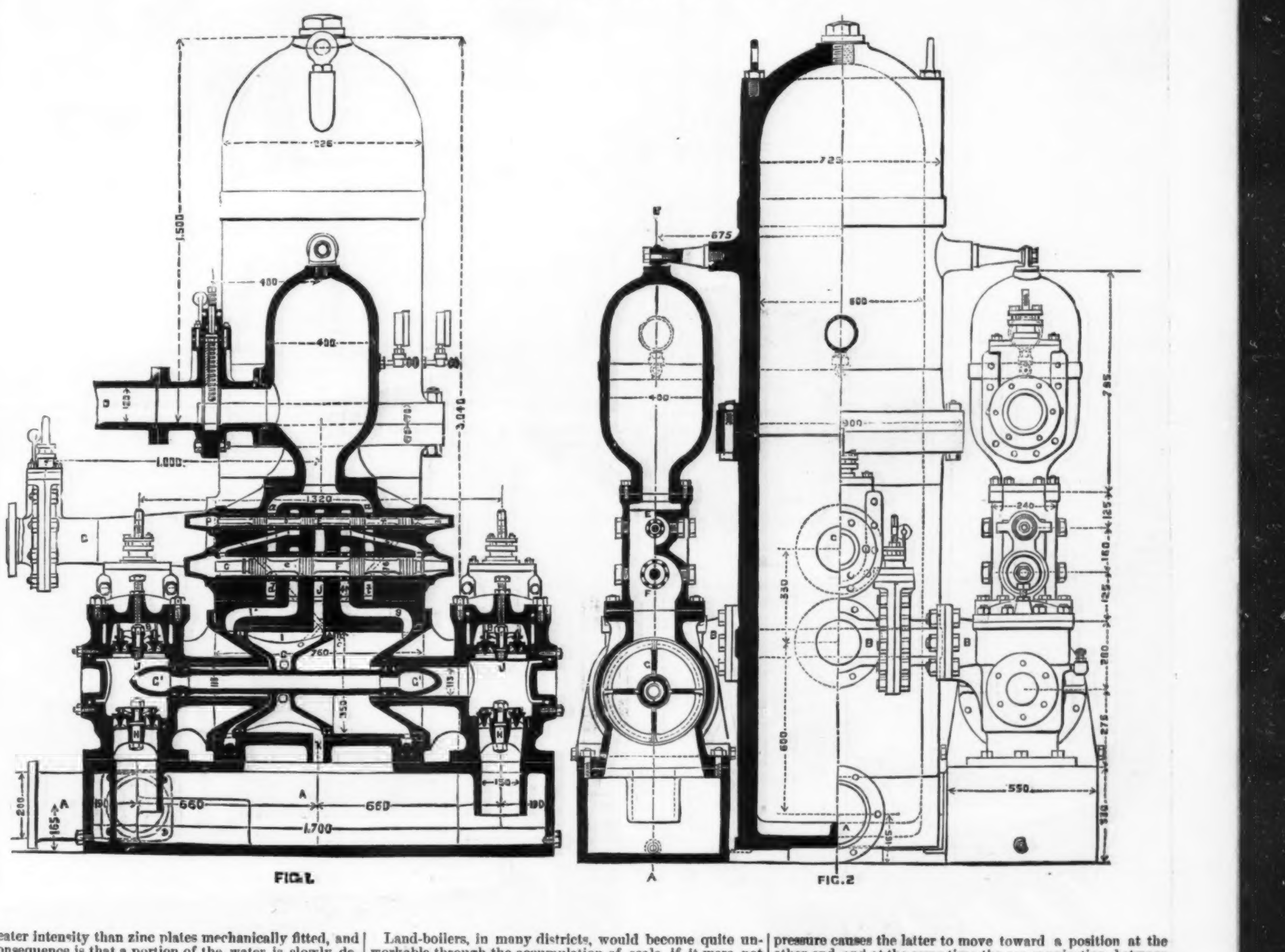


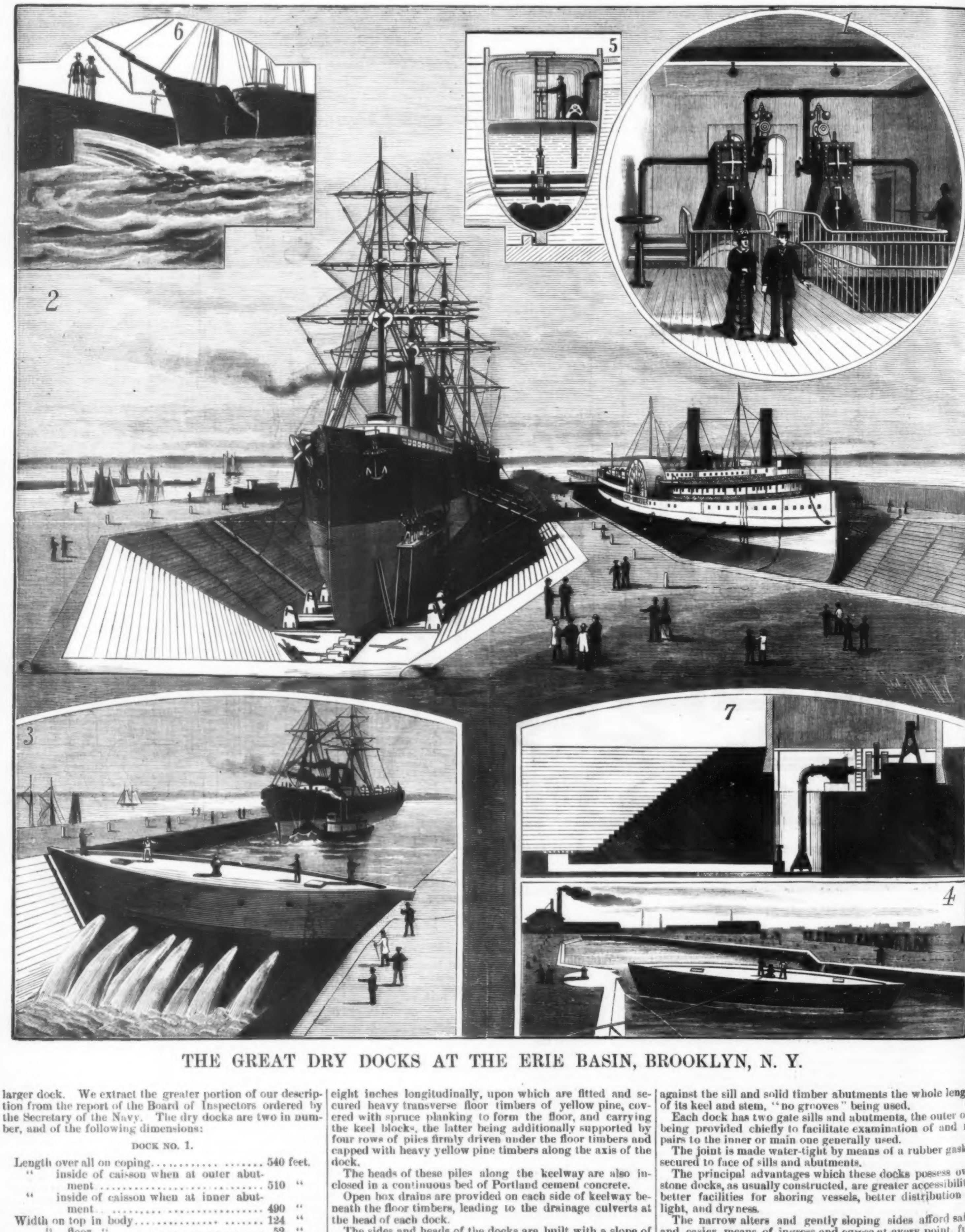
FIG. 1. FIG. 2

TYPE-WRITING has been introduced in the Chicago public schools in an experimental way.

THE GREAT DRY DOCKS AT THE ERIE BASIN.

THE largest dry docks in the country, and probably the largest in the world, are located at the Erie Basin, South Brooklyn, N. Y. These docks were built by J. E. Simpson & Co., of New York, and are now under the control of the William Cramp's Sons Dry Dock Co., of this city, lessees. Our engraving shows the docks and their appurtenances in perspective and in detail; Fig. 1 being a view in the engine room; Fig. 2, the general view of the docks; Fig 3 showing one of the docks while being filled; Fig. 4, the caisson floating away. Fig. 5 is a transverse section of the caisson. Fig. 6 shows the discharge of the pumps, and Fig. 7 shows the dock and the pump connections in section.

The illustration represents the City of Worcester in the smaller dock, and one of the largest ocean steamships in the larger dock. We extract the greater portion of our description from the report of the Board of Inspectors ordered by the Secretary of the Navy. The dry docks are two in number, and of the following dimensions:



THE GREAT DRY DOCKS AT THE ERIE BASIN, BROOKLYN, N. Y.

DOCK NO. 1.

Length over all on coping	540 feet.
" inside of caisson when at outer abutment	510 "
" inside of caisson when at inner abutment	490 "
Width on top in body	124 "
" floor "	52 "
" " at entrance	46 "
" top " "	100 "
Depth of gate still below coping	27 "
" " " high water	22 "

DOCK NO. 2.

Length over all on coping	630 feet.
" inside of caisson when at outer abutment	600 "
" inside of caisson when at inner abutment	580 "
Width on top in body	111 "
" floor "	46 "
" " at entrance	45 "
" top " "	85 "
Depth of gate still below coping	30 "
" " " high water	25 "

The docks are built upon spruce pile foundations throughout, the floor foundation piles being driven in rows spaced three feet from centers transversely, and about four feet eight inches longitudinally, upon which are fitted and secured heavy transverse floor timbers of yellow pine, covered with spruce planking to form the floor, and carrying the keel blocks, the latter being additionally supported by four rows of piles firmly driven under the floor timbers and capped with heavy yellow pine timbers along the axis of the dock.

The heads of these piles along the keelway are also inclosed in a continuous bed of Portland cement concrete.

Open box drains are provided on each side of keelway beneath the floor timbers, leading to the drainage culverts at the head of each dock.

The sides and heads of the docks are built with a slope of about 45°; the alters to high water level are of yellow pine timber, nine inches rise and ten inches tread, and bolted to side brace timbers, which are supported by piles and abut upon the ends of the floor timbers.

The alters are carefully filled in behind with clay puddle, as the sides are built up, and from the level of high water to top of coping the sides are built of concrete *en masse*, faced with Hoope's artificial stone, the alters being continued of the same material to coping level.

The keel blocks are placed upon every floor timber, and bilge blocks of the usual form, sliding upon oak bearers, upon every other floor timber.

Lines of close sheet piling of tongued plank inclose the floor of the dock and also extend entirely around the dock outside of coping, and across the entrance of outer end of apron and at each abutment, forming cut-offs to exclude the tide water, etc.

An iron caisson or floating gate is used to close the dock, made with sloping ends corresponding substantially with the slope of side walls in the body of the dock, which bears against the sill and solid timber abutments the whole length of its keel and stem, "no grooves" being used.

Each dock has two gate sills and abutments, the outer one being provided chiefly to facilitate examination of and repairs to the inner or main one generally used.

The joint is made water-tight by means of a rubber gasket secured to face of sills and abutments.

The principal advantages which these docks possess over stone docks, as usually constructed, are greater accessibility, better facilities for shoring vessels, better distribution of light, and dryness.

The narrow alters and gently sloping sides afford safer and easier means of ingress and egress at every point, furnish a better supply of light and air, and the shoring is more easily adjusted, all of which materially aid in the dispatch and economy with which work of repairs can be prosecuted.

From facts gathered by the inspectors it appears that the life of timber docks is as yet unknown, though the substructure, which is kept constantly wet, can be said to be practically imperishable. Judging from all the information obtainable, the inspectors are of the opinion that the repairs of a timber dock of good quality, of good materials, and well built, would be insignificant for a period of say twenty years, when it would probably be found necessary to renew all woodwork above high water level, and the face timber above half tide level.

The relative average yearly cost of repairs of these docks as now constructed and the ordinary stone docks would, it is thought, be in favor of the timber docks, especially in latitudes much above the frost line.

The manner and cost of operating does not appear to differ materially from other kinds of well constructed excavated docks.

The dock is emptied by two Andrews centrifugal cataract pumps, each driven by a vertical engine, having twenty-four inches diameter of piston and twenty-four inches stroke.

These engines are ordinarily run at fifty revolutions per minute, and by spur gearing between the engines and the pumps the revolutions of the latter are double those of the former.

The dimensions of the pumps were given to us as seven feet in diameter and three feet in width, and the effective capacity of each as twenty-three thousand five hundred gallons per minute. The dock No. 1, at present in use, has, it is said, been emptied, while holding a ship of four thousand tons measurement, in one hour and eight minutes.

The Board is impressed with the efficiency of the caisson of the peculiar shape employed by Mr. Simpson; the sloping ends of the caisson and absence of grooves in the abutments permit the removal of the caisson and the opening and closing of the dock in the shortest time without difficulty and with the least handling of water ballast.

An underground steam pipe from the pumping engine boiler leads to the entrance, whence steam is conveyed to the pumps on board the caisson by flexible hose, and the expense and care of a boiler on the caisson thereby avoided.

TORPEDO BOATS.

MR. YARROW recently read a paper at the United Service Institution on "Torpedo Boats," and, as was naturally to be expected, the reading of a paper by so good an authority on this subject was very well attended. The question was taken up at the stage when torpedo boats had so far established their value that a large order for 100 was made suddenly by Russia. This was in 1877. These boats were to be capable of keeping the sea for a few days, but at the same time to be small enough for conveyance by rail from the Baltic to the Black Sea. With this view they were made 75 ft. long and 10 ft. beam. Five Russian and two English firms supplied them. Messrs. Yarrow supplied working drawings and as many sets of machinery as could be completed and delivered before the closing of the navigation of the Baltic. In November, 1877, the first boat was tried on the Neva, when it obtained a speed of 18 knots. Several boats were forwarded by rail to Sebastopol with the funnel only removed. The journey occupied a week, and they were found fit for immediate sea-going on arrival, and gave entire satisfaction. About this time the English Government ordered our first boats of the "Lightning" type. A few months later, in 1878, some more were ordered from various firms. Messrs. Yarrow supplied one which obtained a speed of 21·94 knots at Long Reach, where it was tried under Admiralty conditions, in the spring of 1879, beating its rivals by nearly two knots in speed. The load carried was 6¾ tons, consisting of torpedoes, gear, coal, etc. This boat had a forward rudder fitted to it to improve its steering powers, by which means it was enabled to turn in a very small circle. In 1878 two first class torpedo boats were built for Russia, but not allowed to leave the country, and eventually purchased by the Admiralty. An accident with one of these led to the introduction of an important feature, namely, a system of light non-return valves, so arranged that any back rush of flame or steam closed them and cut off all communication between boiler and stokehole. This has proved its value since, and has become generally adopted.

In the end of 1879, a larger boat or torpedo cruiser was made for Russia, called the Batoum. She carries coal for a run of 800 miles at moderate speed. She is 100 ft. long and 12½ ft. beam, with engines indicating 500 horse power. She carries four fish torpedoes discharged through two launching tubes placed parallel to the center line of the boat and projecting just beyond the bow. Steering and discharging are effected from the conning tower. There are three short masts to supplement the steam propulsion if necessary. The Batoum ran from London to Nikolaief in about eighteen days—4,800 miles—averaging 11 knots per hour. Her speed over the measured mile was 22 knots.

Many boats of this type were afterward ordered by the Argentine, Greek, Brazilian, Austrian, Dutch, and Italian governments. Those for the first named power were rigged for sailing, and went to Buenos Ayres well, the quickest in seventy-two days. Their sea going qualities were reported to be so good in rough weather, that there clearly is no need to increase size for the sake of safety. In 1879 and 1880, thirty-four second class torpedo boats were made for the Admiralty to equip large ironclads, by Messrs. Thornycroft and also Yarrow & Co. At first the torpedoes were discharged while the boats were nearly at rest from cradles lowered into the water. Subsequently a steam impulse gear devised by Messrs. Yarrow was substituted. The maximum speed of these second class boats is about 17·27 knots, continuing for two hours.

A collision occurring to a torpedo boat in Italy led to Messrs. Yarrow making a special arrangement to prevent water entering in such a way as to cut off the supply of air to the fire, which has worked admirably, and did not in any way tell against the boat's powers of moving, a mean speed being obtained with a boat so fitted of 22·4 knots. All torpedo boats have curved decks, which give the maximum of strength against compression. No special improvements or new features have come in during the last year. A remarkable trial may be noticed, however, of two torpedo boats for Russia—one built by Messrs. Thornycroft and the other by M. Normand. The former boat was 113 ft. long and 12½ ft. beam; she had a speed of 18·96 knots per hour for three hours, burning 2 tons 19 cwt.—with 633 indicated horse power—or 1 ton per hour. With 13·39 knots speed, 13 cwt. 3qr 8 lb. of coal was burnt in two hours with 212 indicated horse power. M. Normand's boat, which was 124 ft. by 11⅚ ft. beam, 18½ knots was obtained for three hours, with 1 ton 19 cwt. of coal and 574 indicated horse power. During four and a half hours 11·57 knots speed was kept up, with 240 lb. of coal per hour and 121 indicated horse power. The relative value of the fuel is not known. The French boat was peculiarly steady and free from vibration.

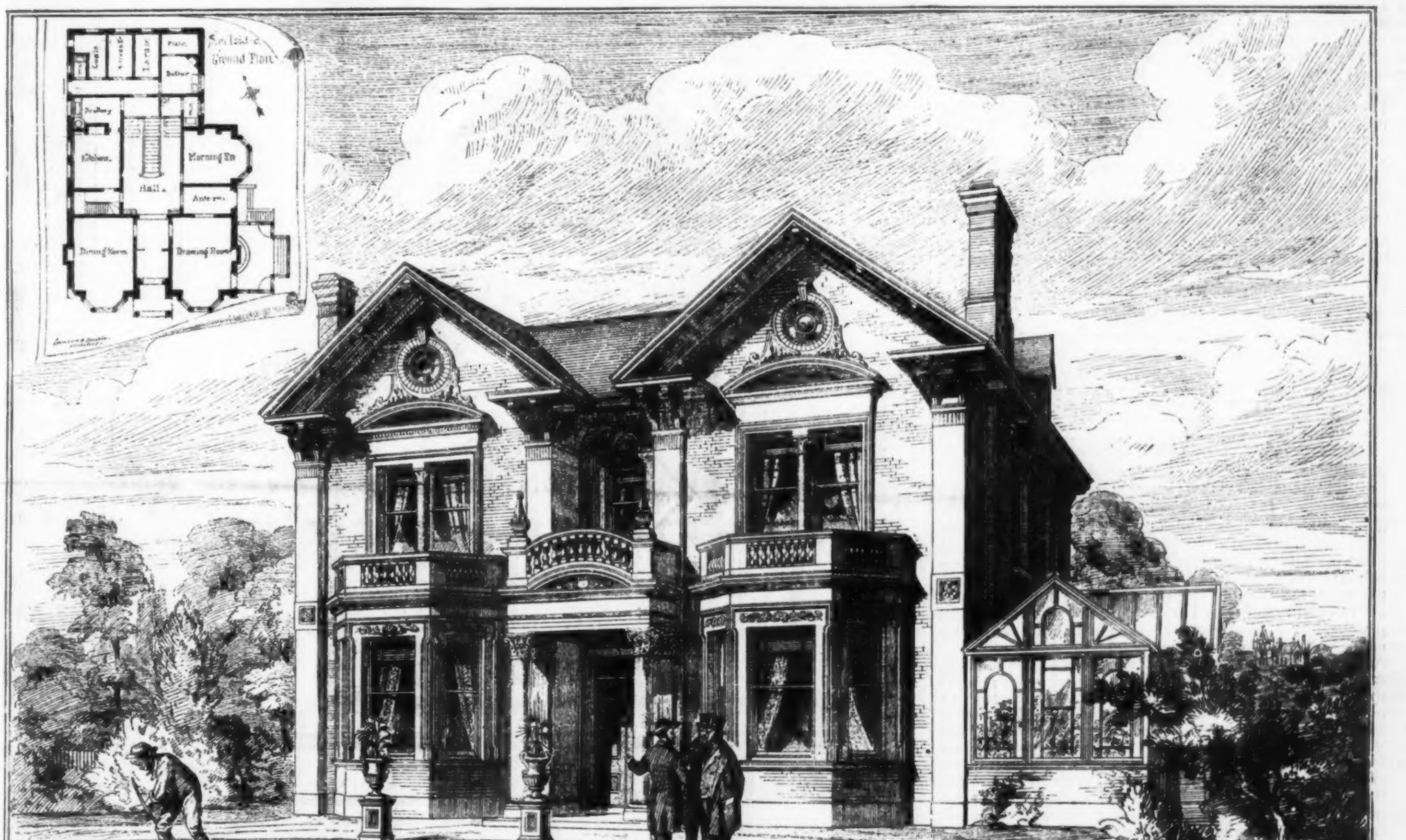
Two first class torpedo boats are being built for England with revolving torpedo guns. A drawing was submitted of a torpedo boat protected partially with steel plates on the sides 1½ in. and on the decks 1 in. thick; but Mr. Yarrow did not advocate it as a good arrangement. The present second class torpedo boats Mr. Yarrow considers rather long, narrow, and unhandy, and he prefers boats 56 ft. long by 9 ft. beam, with a speed of 15 knots; the loss in this respect being, it is thought, more than compensated by the boat taking a machine gun, and being handy, seaworthy, and available as an ordinary fast steam launch. Mr. White, of Cowes, has recently designed a remarkably good boat deserving notice.

With regard to the behavior of torpedo boats on service, it is not surprising to find that when they get at all out of order, and in inexperienced hands, their performances should fall far short of those achieved on trial. In a recent test at Pola, boats 100 ft. long and 12½ feet beam, supplied to Austria, obtained a speed of 20 knots when fully equipped with torpedoes, coals, and with a crew, just as for action. This shows what may be achieved when attention is given to the matter. In the Italian service a very complete system of training men has been introduced, as well as in the Austrian service. It is to be hoped that this subject may receive the attention of our own authorities. England, however, is far behind in the number of boats she possesses. Russia has 115 of these torpedo boats, France 50, Dutch 22, England 19, Italy 18, Austria 17. This deals only with boats 75 feet long and 10 ft. beam, fit for sea in all weathers.

The Russian Government possesses one boat to 18 miles of coast line; the Dutch one boat to 22 miles of coast line; the French one boat to 33 miles of coast line; the Austrians one boat to 47 miles of coast line; the Italians one boat to 153 miles of coast line; the English, comprising only England, Wales, Scotland, and Ireland, one boat to 197 miles of coast line; and if the colonies are included, at the highest possible estimate there is one torpedo boat to 800 miles of coast.

AN ELECTRICAL TORPEDO BOAT.

Last year Messrs. Siemens and Messrs. Yarrow together made a boat 40 ft. long and 6 ft. beam, which obtained a speed of eight miles per hour. The electricity was stored up in accumulators below the water line, such as could be charged by the machines now carried on many men-of-war. Such a boat would move without noise, and would have no funnel or fire to betray it. It might either discharge Whitehead torpedoes or drive a spar torpedo, the electricity being available for ejection. Probably, however, torpedo boats driven by electricity will be the exception, not the rule.



SUGGESTIONS IN ARCHITECTURE.—SAN ISIDRO, POOLE ROAD, BOURNEMOUTH.

SAN ISIDRO.

To borrow a term from the political arena, this is a type of house which may be described as conservative in its principles and general character—a fact probably to be attributed to the irony of circumstances, as few opportunities would slip its owner for displaying an opposite bias. No eclectic promptings have moved the pencil of its author, and the most skeptical might peer in vain for any indications of a gentle penchant for some of the pretty conceits of his favorite queen. Its surroundings are all of an equally familiar kind; the garden and drive in front, the tennis courts behind, the south sea aspect, the views from the flat at the top, with the pines in the foreground and the bay and ships in the distance, are all mirrored as soon as touched upon. In accommodation it is very complete; there are the regulation

size dining, drawing, and morning rooms, with the usual complement of kitchens and offices, etc., on the ground floor. A fine billiard room is entered from the landing of an imposing two-way staircase immediately opposite the entrance, and four best bedrooms, two dressing rooms, bath room, and seven secondary rooms go to make up the rest of the family requirements. The heating arrangements have been effected by hot water coils in the hall and open fires in the rooms. The walls are all constructed with a 3-inch cavity, and that comprising the front, given in the illustration, is executed with Fareham red bricks, with stone dressings, and portico; Messrs. Lawson & Donkin, of London and Bournemouth, being the architects.—*The Architect.*

PREPARATION OF LANTERN SLIDE.

THE grand difference between collodion and gelatine as regards development is comprised in the fact that when collodion plates are under treatment, the image by reflected light is never lost sight of (we are now speaking particularly of lantern slide work); the unchanged parts of the film must retain their purity, and great contrast on the surface be maintained throughout; this is absolutely essential, in order to secure vigorous results, clean and clear high lights, and freedom from dinginess, a quality fatal to a lantern slide. In developing collodion or emulsion lantern slides, the operator is guided much more by the surface appearance than by the condition when looked through, although both these circumstances have to be taken into consideration in seeking the final result. There must be density of image without opacity, and there must be clean glass in the highest light without any evidences of under-exposure and corresponding hardness and lack of half-tone. Nothing but experience can lead the operator to success, and until complete mastery is obtained over the process of development, perfect results cannot be expected. We speak feelingly on this subject, for we have washed off dozens of plates when learning to develop to obtain a certain quality of image. Therefore, we urge our readers to practice and learn the development, so that the greatest control can be held over this important stage of the process.

There are at least three ways of employing collodion emulsions for the production of lantern slides. We will signalize them thus:

A—Collodion emulsion used "unwashed," the plates exposed and developed wet.
B— ditto "washed" ditto
C— ditto ditto used dry.

Let us now consider the preparation of an emulsion of collodion whose properties are essentially applicable to lantern slides. We shall give several formulæ, beginning with the simplest, and in each case the quantities given will be to produce eight ounces of emulsion.

FORMULA FOR AN UNWASHED COLLODIO-BROMIDE EMULSION WITH FREE BROMIDE.

Quantities.

Pyroxyline	40	grains.
Absolute alcohol	4	ounces.
Methylated ether (0·725)	4	"
Double bromide of cadmium and ammonium	90	grains.
Nitrate of silver	125	"

Employment.

We have obtained very excellent pyroxyline from Messrs. Hopkin and Williams, Cross Street, Hatton Garden, at one shilling per ounce. Dissolve the forty grains in a wide-mouthed clean bottle fitted with a nice soft cork, and pour in the whole four ounces of ether and three ounces of alcohol. The cotton will dissolve directly, and no filtering need take place, but at once weigh out the ninety grains of double bromide, and add to the plain collodion.

Put the 125 grains of nitrate of silver into a small boiling-flask, add a few drops of distilled water, heat over a spirit lamp until dissolved, and then add carefully one ounce alcohol; this requires a little skill to obtain an alcoholic solution of the silver nitrate, for if the alcohol be very pure, and very little water is used, the silver will be thrown out of solution, and will require some trouble to get it again into solution. The alcoholic solution of silver must be made pretty hot, say 120° Fahr., and then, in the dark room, it must be poured into the bromized collodion in quantities of about a drachm at a time, instantly corking the bottle and shaking vigorously between each addition of silver until the whole is got in, when the resulting emulsion should show quite smooth and of a reddish yellow color when shaken against the sides of the bottle. Great care should be taken to prevent loss of ether by evaporation, due to the rise in the temperature brought about by additions of hot alcoholic solution of silver, or precipitation of the cotton and bromide of silver will ensue, and when this happens it is extremely difficult and sometimes impossible to get them into solution or suspension again.

Frequent shaking of the bottle so as to prevent the silver bromide from setting as a hard cake at the bottom will conduce to the production of a rich and creamy emulsion of fine texture, and a warm temperature will favor this end. Collodion emulsions may be said to emulsify or become sensitive just as gelatine emulsions do, but in the former case it takes as many days to produce the result which can be arrived at in minutes by boiling a gelatine emulsion. We cannot boil a collodion emulsion, for even at ordinary temperatures the ether and alcohol evaporate rapidly enough, and no satisfactory method of emulsifying bromide of silver in collodion appears yet to have been brought into a workable condition, which will give any better results than the mere effect of the change which goes on at ordinary temperatures, which, as before hinted at, occupies several days.

If the emulsion we have just described be tried the day after mixing it will be found very insensitive, giving hard pictures and no half-tone. It is very interesting to coat a plate every day and notice the gradual increment of rapidity, and with the rapidity come also robustness of image, warmth of tone, facility of development, sensitiveness to half-tone, and all the other concomitants of a wet collodion plate made by the bath process when everything is in first-rate working order. Yes, more, for a well-made, carefully balanced emulsion at its best will be more rapid, and certainly more vigorous in quality of image, than a bath plate.

Rapidity in a collodio-bromide emulsion for lantern slides is not a quality that need be eagerly sought after; we would at any time sacrifice speed in order to obtain density, vigor, brightness, entire freedom from fog, and withal the right degree of transparency even in the deepest shadows or blacks. All these qualities can be got in a collodion emulsion, not at once, but by maturing or ripening, and then using up the emulsion without much delay, or by then pouring it out to set and "wash;" of which more anon.

We have had emulsions which have ripened into splendid order in three days in summer, but the average period is about ten days, the usual minimum being seven days, and the maximum twelve days. Much, of course, depends upon the relation of free bromide to the silver, the qualities of the cotton used, the bromide salt employed, the temperature, and other causes. We strongly advise the reader to make up an emulsion according to the foregoing formula; it is excellent practice.—*Photo. News.*

THE RESIN INDUSTRY IN THE LANDES DEPARTMENT.*

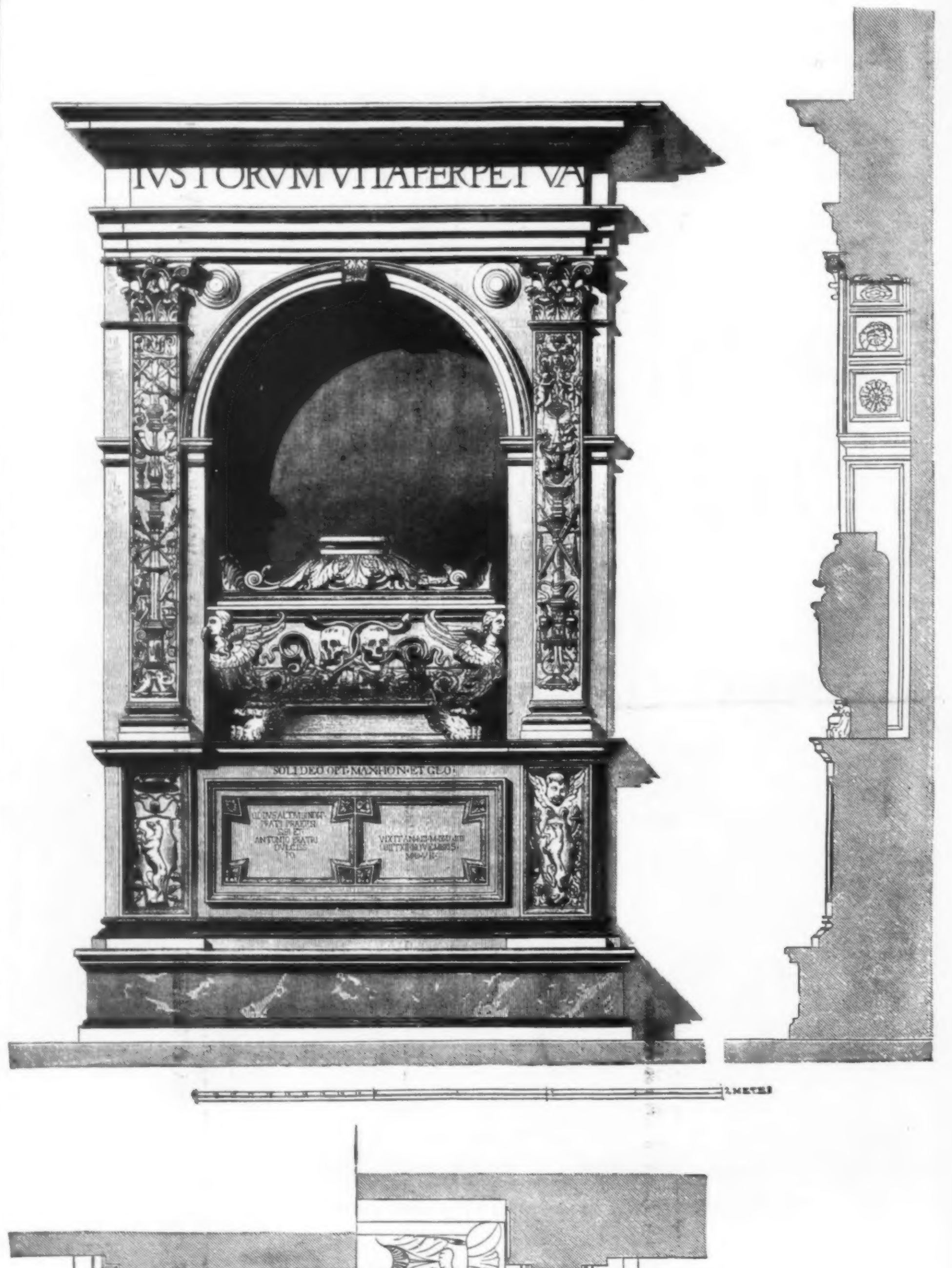
By A. RENARD.

THE Landes department is the most important center in France for the production of resin. This large triangular space of about 14,000 square meters, bounded upon one side by the ocean, and on the others by the Adour, the cultivated heights of the Lot et Garonne department, and the vineyards of Bordeaux, is an ancient bed of the sea, covered by sand of the Pliocene age. The sandy masses, which in many places are more than 80 meters thick, contain a few beds of clay; but at only a slight depth there occurs a compact layer termed *alois*, which is traversed with difficulty by the roots of trees, and which is one of the greatest obstacles to forest vegetation. In former times the rain water, retained by this compact layer of sandstone, remained upon the soil and transformed the surface of the Landes into a vast marsh; but since then numerous drainage ditches have been cut, and convey the surplus water to the pools on the shore. In this way the surface has now become almost dry, the marshes have disappeared, and the inhabitants of these districts are no longer compelled to raise themselves on stilts to traverse the vast stretches of land which formerly were impassable to ordinary pedestrians.

There is no doubt that before the middle ages the greater part of the Landes was covered with forest, at least upon the borders of the sea; but through the improvidence of the inhabitants these woods had been destroyed, and the sand had commenced its invading march from the seacoast, threatening to swallow all that it met upon its way. The first attempts which were made to reclaim the "dunes" date from the commencement of the eighteenth century; but it was Brémontier who, between 1787 and 1793, definitively solved the problem of the plantation of the Landes, he succeeding in consolidating more than 250 hectares of shifting "dunes." In the present day an immense forest of pines covers all this vast extent of territory, formerly uncultivated and marshy, and forms an impassable barrier to advance of the "dunes" from seaward.

The maritime pine is the tree chosen, to the exclusion of almost all others, by the Landais cultivators, and its reproduction is effected either from seeds or from cuttings; but the finest trees are those obtained from seeds, and this is the method generally followed. The sowing takes place naturally. Every four or five years a clearing is made by cutting down the least vigorous of the young trees so as to allow the others to develop under the most favorable conditions, and at the end of twenty-five or thirty years the trees are about 1½ or 2 meters apart. Those which at this stage still require to be removed are bled to death. This operation consists in making two large gashes on opposite sides of the tree, the turpentine that exudes being collected by one of the methods described subsequently. Under these conditions the tree is quickly exhausted, and at the end of four or five years is cut down. Eventually a final selection is made of the finest trees in the *pignada*, which are to be preserved for regular working, care being taken that they shall be equidistant at about 8 meters; all the others are then bled to death and cut down at the end of from five to seven years. When the trees selected for preservation, which are called *pins de place*, have attained a diameter of 30 to 35 centimeters, they are ready for working.

By means of a sharp blade, slightly curved and fixed perpendicularly at the end of a wooden handle, an incision is made at the base of the tree on the side facing the east, and this is retouched every three or four months. The cutting is commenced in April and continued until the end of September, during which time it should reach a height of about half a meter. Care, however, is taken early in the season, about the beginning of March, to define the extent of the incision by removing the external surface of the bark from the part of the tree which is to be denuded. The following



SEPULCHRAL MONUMENT OF ALTOVITI DI ROVEZZANO IN THE CHURCH S APOSTOLI AT FLORENCE (1507).—*From The Workshop.*

* From the *Moniteur Scientifique.*

year the incision is continued upward,and afterward for five consecutive years, until a height of 2¼ or 3 meters is reached. A similar operation is then commenced on the side of the tree exposed toward the south, and by the time this has had its turn a return can be made to the first incision, which has become cicatrized. When the operation is well conducted, a tree can be thus bled during more than two hundred consecutive years (*pendant plus de deux cents annee consecutives*).

Two methods are in use to collect the exudation. The older one, which is the most simple, consists in making a small trench at the base of the tree, in which the runnings from the tree collect. While the incision is near the ground, the collection is effected fairly well; but after two or three years, when the incision has attained a considerable length, the exudation reaches the ground with difficulty. Under the influence of wind and sun the greater part of the essential oil is volatilized or resinified, and the collection becomes insignificant. The second method, called "Hughes' method," after its inventor, partially avoids these inconveniences, and, besides, has the advantage of yielding a "gemme" much more free from soil and vegetable *debris*. It consists in affixing to the tree by means of a nail a small pot, which is placed every year under the fresh cut. The turpentine thus caught, having to run a less distance to reach the recipient, is always richer in essential oil than that obtained according to the older method.

The collection of the "gemme" is made every two or three weeks. The pots are first emptied into a vessel of 40 or 50 liters capacity, from which the contents are transferred to a large trench in the ground capable of holding 400 or 500 liters, from which the casks are filled when required for sale. In October the resin that has solidified on the tree is gathered. This can be added to the other portion for the purpose of distillation, but usually it is kept separately, and

ligneous matters, is introduced into a copper receiver of a fixed capacity of 300 liters. At the bottom of this pan there is a pipe fitted with a tap, the other end of which opens at about 8 inches from the bottom of the still in which the distillation has to be effected. The still is of copper, and furnished with a worm that dips into a wooden receiver full of water. Three hundred liters of "gemme" are run in and heated strongly. The oil commences to distill over, and at the end of fifteen or twenty minutes about 80 or 100 liters of hot water are run into the still through a tap fixed in the upper part of it. This addition of water has for its object to facilitate the volatilization of the remainder of the essential oil. The distillate is received in a vessel made of sheet iron and fitted at its upper part with a capacious pipe by which the essential oil, being lighter than water, passes off into the casks set for its collection.

When the liquid issuing from the worm no longer contains much essential oil, the supply of water is stopped; the distillation is then continued for a few minutes more, and the operation is finished. The yield of essential oil varies with the season, and is about 15 to 18 per cent. of the weight of the "gemme." The exit pipe at the bottom of the still is then opened, and the "brai," or resinous residue, is run into a sheet iron tank, after having been made to pass over a copper plate pierced with holes, so as to eliminate various impurities that it may contain. The apparatus is then ready for a fresh operation, which is commenced without allowing it to get cold. In this way eight or ten distillations are effected daily.

After the "brai" has been allowed to cool for some time, it is run into wooden casks, where it solidifies. That which is derived from "gemme" collected by Hughes' method is sent into commerce under the name of "yellow colophony," and that obtained from "gemme" collected by the old method, is sold under the name of "brai clair." The resins of

SUGGESTIONS IN DECORATIVE ART.—DESIGN FOR CABINET AND CHAIR.—*From The Workshop.*

sent into commerce under the name of "galipot" or "barasse."

The "gemme" is the primary material for the manufacture of oil of turpentine; it is a mixture or rather a solution of colophony in the oil. Under the influence of heat the oil is volatilized, and the colophony is left as a residue. The industrial distillation of the "gemme" is carried on in small factories, usually situated in the midst of the forest. The season commences in the month of May, and terminates in October.

On the arrival of the "gemme" at the factory it is decanted into two large wooden vats capable of containing 100 barrels of 340 liters each. By means of a kind of saucepan fastened to the end of a long wooden staff, the material is dipped from these vats and introduced into two large copper boilers, known as preparatory boilers, of 6 to 8 barrels capacity. In these boilers the "gemme" is heated during a whole day over a low fire. The water collects at the bottom, while foreign substances, such as chips of wood, twigs, etc., rise to the surface, from whence they are skimmed off and put to drain in straw filters arranged above the second boiler. In the evening the fire is allowed to go down, and the boiler is left to itself. In the morning the "gemme," freed in this way from the water that it held in suspension and which frequently amounts to 12 or 15 per cent., as well as earthy and

inferior quality, or "brais noirs," are obtained by the same method, but are the product of the distillation of the less pure portion of the "gemme" which collects toward the bottom of the preparatory boilers.

Sometimes the "brai," instead of being run directly into casks, is used for the manufacture of resin. In this case, upon issuing from the boiler of the still, it is run into a special vat, and while it is still liquid about 15 to 20 per cent. of hot water is added, in quantities of 20 to 30 liters at a time. The mixture is stirred energetically with staves until the whole mass has become opaque and thoroughly homogeneous; then it is run through a trough in sand into cylindrico-conical moulds also in sand, where it solidifies. The resin thus obtained is of a pale yellow shade and under the name of "yellow resin" or *resine de boutique*, is used in the making of resin candles.

The straw filters, upon which have been deposited all the impurities collected upon the surface of the preparatory boilers, are used for the preparation of a further quantity of "gemme" of inferior quality. They are introduced together with the detritus remaining upon them into a kiln, resembling a lime-kiln, known as a *four à pègle*. The fire being lighted and a portion of the material burnt, determines the liquefaction of the "gemme," which runs off through an orifice situated in the lower part of the kiln into a receiver containing water. This "gemme," submitted to distillation, yields about 10 per cent. of its weight of essential oil.

MANUFACTURE OF RESIN OILS.

This industry dates back half a century, and at the present time has attained a considerable development. In 1832 M. Dives, while distilling "gemme" for the extraction of oil of turpentine, made the observation accidentally that in continuing the operation beyond the point when only colophony was left in the still, this was decomposed, giving rise to an oil. He therefore replaced the copper alembics by cast iron retorts, and the mode of distillation which he adopted is the same as is employed at the present time.

Eighteen hundred kilogrammes of "brai" are introduced into a large hemispherical cast iron boiler, heated over arches, together with 1½ or 2 per cent. of lime, added with the object of rendering the oils more fluid. The boiler is covered with a copper dome, which is luted with clay; this is in communication with a worm, also in copper, disposed in a vat full of cold water. Pine wood is employed as fuel in heating the boilers. The operation is commenced at three o'clock in the morning, the fire being urged strongly at the commencement, and in two or three hours the distillation begins; the fire is then moderated and maintained so until seven in the evening. The distilled products are received in a small sheet iron vessel, having in its upper part a tube by which they can be passed into the casks. At the commencement of the operation water passes over, which is run off through a tap placed in the lower part of the receiver. Afterward about 25 kilogrammes of a light fraction are collected, and then 9 or 10 barrels of oil, each containing 160 kilogrammes. At the end of the operation the bottom of the boiler is brought to a dull red heat. There remains then only a solid carbonaceous residue, which has to be removed by means of a pick after each distillation.

The total yield in the lighter fraction and resin oils is about 80 to 85 per cent.; the principal loss is due to the combustible gases which are given off in abundance during the whole of the operation, and which have not hitherto been utilized.

The resin oils thus obtained are not identical throughout the entire distillation. They are distributed generally, according to their color, into three classes: pale oils, blue oils, and green oils.

The "pale oils" are the most abundant, the quantity reaching 1,100 or 1,200 kilogrammes in each operation. They are of a brownish yellow color and rather fluid. In density they vary between 0·990 and 1·000. They are incongealable, even at very low temperatures. They possess considerable lubricating properties, but present the inconvenience of resinifying rather rapidly in contact with the air, which, together with their odor, has always limited their employment. Railway companies and miners use large quantities for lubricating machinery, after adding 25 to 50 per cent. of colza or mineral oil. They are also employed, either alone or mixed with linseed oil, in the manufacture of printing ink

The "blue oils" consist of that portion of the products which passes over immediately after the pale oil. These oils are more colored and have a very pronounced blue fluorescence. Their density is about 0·990 to 1·000.

Lastly, when the operation approaches its termination, the "green oils" are collected, which are of a still darker shade, and possess a very strong green fluorescence. They are always mixed with a very large proportion of water, from which it is extremely difficult to free them. These oils, like the "blue oils," are more fluid than the "pale oils;" they contain, in fact, a larger proportion of a light spirit, the presence of which is due to the commencement of pyrogenation, which the colophony undergoes in consequence of the high temperature to which the distillatory apparatus is submitted.

The blue and the green oils are employed especially as lubricants for wagons used in mines. As to the light spirit, the proportion of which amounts to 1 or 2 per cent. of the colophony distilled, its employment is very limited. It possesses a very pronounced odor, is brownish in color, and has a density of about 0·950. Exposed to the action of the air it resinifies rather rapidly, similarly to oil of turpentine. Occasionally it is used in the place of oil of turpentine, especially in making up paint for outdoor use.

The resin oils obtained by the method indicated are usually sent into commerce in the same condition. They are then frequently turbid and slightly opalescent through the presence of a small quantity of water distributed through the mass. In order to render them limpid, M. Durou has proposed to allow them to stand some time in large reservoirs arranged under glass roofing, exposed to the sun. Under the influence of heat and light the oil clarifies pretty rapidly, especially in summer, and at the same time undergoes a slight decoloration. The same result is also attained by a rectification, and for this purpose the apparatus used in the distillation of the colophony is employed. The operation should be conducted slowly. A certain quantity of light spirit is first collected and set aside, after which the oil distills perfectly clear. This distillation yields very good results, but always occasions a loss of 6 to 8 per cent. The rectified oil has a density of 0·972. Several processes have been proposed for removing from resin oils their odor, which in many cases constitutes an obstacle to their employment. Washing with soda, followed by agitation with sulphuric acid, is the process which appears to yield the best results, but this method of purification has not yet received any industrial application.

When a lubricant for carriages is required, the "brai" is submitted to a rapid distillation not lasting more than four hours. The oil obtained under these conditions then contains a large proportion of resin, which has been carried over mechanically; it is viscous and thick, and is known as "strong" oil. To prepare the lubricant, one part of slaked lime is suspended in two parts of thin oil from a slow distillation, and one part of the thick paste so obtained is incorporated with four or five parts of "strong" oil. The resin contained in the latter combines with the lime to form a resinate of lime. The paste is stirred well, and then while still liquid it is run into barrels or boxes, where it acquires quickly the desired consistency. These lubricants are sometimes colored by the addition of powdered pigments.

THE Alps contain two peaks above fifteen thousand feet, six or seven above fourteen thousand feet, and in all about thirty which are called first class peaks. The Himalayas, on the other hand, or rather the limited part of them with which we are familiar, contain peaks from twenty-nine thousand feet downward. More than one thousand have been measured exceeding twenty thousand feet, and it is computed that at least two thousand exceed this height.

CUPRO-AMMONIUM SOLUTIONS AND THEIR USE IN WATERPROOFING PAPER AND VEGETABLE TISSUES.

By C. R. Alder Wright, D.Sc., F.R.S.

The term "cupro-ammonium compound" is usually understood by chemists as indicating a member of the class of substances obtainable by the combination of ammonia with certain copper compounds, so as to give rise to a "metallo-ammonium" derivative containing copper. Salts of copper, *e. g.*, copper sulphate, usually combine with four proportions of ammonia; thus the *cupro-tetrammonium sulphate* $(Cu.4NH_3)SO_4.H_2O$, is obtainable in crystals, by simply pouring a concentrated solution of copper sulphate into a solution of ammonia, in such proportions as to obtain a clear deep-blue liquid, and then precipitating the crystallized salt by adding a considerable quantity of highly concentrated ammonia solution, or by shaking with alcohol; in a similar fashion numerous other cupro-tetrammonium salts can be obtained.

A closely related compound, but possessing somewhat different properties, is *cupro-ammonium hydroxide*, prepared by dissolving cupric hydrate in ammonia solution, or by agitating together metallic copper and ammonia solution in presence of air, when the copper oxidizes and dissolves in the ammoniacal liquor, forming a deep-blue liquid, sometimes termed "copperized ammonia;" probably the cupro-ammonium compound present is $(Cu.4NH_3)(OH)_2$, related to the hydrated copper oxide formed as cupro-tetrammonium sulphate is to copper sulphate.

Most of these compounds are very unstable, breaking up under the influence of heat and water alone, or conjointly; thus cupro-tetrammonium sulphate treated with a large bulk of cold water is partly decomposed, forming a basic insoluble copper sulphate, together with free ammonia and ammonium sulphate; cupro-ammonium hydroxide solution is decomposed by simple addition of alcohol to its ammoniacal solution, a blue substance essentially consisting of hydrated copper oxide being precipitated; the same result ensues on boiling, save that anhydrous black copper oxide is then formed, ammonia being driven off.

In presence of a large excess of ammonia, the instability is less marked in all cases; the strongly ammoniacal fluids formed by dissolving copper salts or copper hydroxide in a considerable excess of ammonia water are the "cupro-ammonium solutions" referred to in the present paper.

It has long been known that these solutions possess the power of apparently dissolving cellulose and various allied substances; thus paper, cotton wool, and similar materials, when digested with these fluids, disappear, and are apparently truly dissolved. It is held, however, by some chemists (*e. g.*, Erdmann, *Jour. Prakt. Chem.*, lxxvi., 385), that these are not cases of true solution, but that the substances are simply gelatinized and disseminated through the fluid in a transparent form, as starch is in water.

On the other hand, on neutralizing the fluid by an acid, or better still, on adding potassium cyanide solution until the blue tint is discharged, the cellulose reappears as a gelatinous precipitate; this result would suggest that the reappearance of the cellulose is brought about by the destruction of the solvent in which it was truly dissolved, viz., the cupro-ammonium compound, by conversion into ammonia and cupro-cyanide (or into ammonic and cupric salts, if an acid be used).

On evaporation to dryness of a cupro-ammonium solution in which cellulose has been dissolved, a more or less gummy mass is formed, containing the cellulose intermixed with copper oxide, and with ammonia and copper salts if a cupro-ammonium salt were used, but containing copper oxide and a green copper derivative or compound of cellulose if cupro-ammonium hydroxide were employed. When the cellulose is in excess, *e. g.*, when the solution is evaporated on the surface of paper, calico, etc., just dipped in the solution, black oxide of copper is often not formed at all; but a green, varnish-like mass of cellulose conjoined with copper oxide, or of the copper salt of some feeble acid derived from and closely akin to cellulose, coats the surface of each filament of the fabric used, welding and cementing them together. This cement-like *cupro-cellulose*, as it may be termed, being insoluble in water, communicates water-resisting properties to the material so treated; moreover, the presence of copper renders the dipped and dried substance less prone than before to the attacks of insects and mould, so that animal and vegetable life of a parasitic nature and fungoid growths are rarely, if ever, to be observed in the substances, even when kept under conditions where boring worms, ants, rot, and mould would be likely to attack them.

To produce the best results in this direction, solution of cupro-ammonium hydroxide is, for many reasons, preferable to solutions containing cupro-ammonium salts; not only is the action on cellulose more energetic for a given amount of copper and ammonia in solution, but various other advantages are gained. For example, if ammoniacal solution of cupro-ammonium sulphate be used, the dried treated fabrics will contain ammonium sulphate, and sometimes copper sulphate, soluble in water, rendering the material porous if exposed to the action of water in sufficient quantity to dissolve out the soluble matters, and causing more or less tendency to unsightly efflorescence under other conditions.

Further, during the drying of materials treated with cupro-ammonium hydroxide solution, all the ammonia present is volatilized, and may be recovered by appropriate means; whereas, with cupro-ammonium sulphate solution, a considerable fraction of the ammonia is fixed in the fabric as sulphate, and so lost.

A peculiar property of cupro-ammonium solutions, and one most important from the manufacturing point of view, is that whereas iron is, as is well known, attacked and dissolved by solutions of ordinary copper salts (*e. g.*, the sulphate, "blue vitriol"), an equivalent quantity of copper being precipitated during the operation, no such action is observable with cupro-ammonium hydrate solutions; so that cast and wrought iron tanks and baths for the reception of the liquor may be used with impunity, as may steel rollers and machinery of all kinds when employed in contact with the liquor, or with fabrics moistened therewith. On the other hand, copper and brass must be studiously avoided in the construction of such appliances, otherwise corrosion and injury is speedily brought about. This peculiarity, as regards the non-action of iron and steel, is the more remarkable in that it is not observed with zinc; this latter metal precipitating copper (and being itself dissolved) with about equal facility, whether the copper be in form of an ordinary copper salt, or in that of a cupro-ammonium solution.

For certain purposes, a bath containing a mixture of cupro-ammonium and the analogous zinc-ammonium hydroxide solutions may be used with advantage; the zinc compound does not of itself sufficiently pectize cellulose to give good results; but when used in conjunction with cupro-ammonium hydroxide, pectizing is brought about by the copper solution, while certain advantages are gained by the simultaneous presence of zinco-cellulose and cupro-cellulose in the finished goods. The subject of the manufacture of both cupro-ammonium and zinc-ammonium solutions having been already dealt with in a paper read before the Society of Chemical Industry (published in a recent number of the *Journal* of that Society), it will suffice, on the present occasion, to state that the fluids are obtained by the simultaneous action of air and ammonia water on metallic copper (or brass, if a mixture of cupro- and zinc-ammonium hydroxides is required), due attention being paid to the recovery of the large amount of ammonia necessarily carried away by the "spent" air during the operation.

The manufacture of fabrics, notably paper and canvas, treated with cupro-ammonium solutions so as to waterproof them and render them rot-proof, and practically free from the attacks of insects and mould, has been recently commenced on the large scale, at Willesden, by the Patent Waterproof Paper and Canvas Company, Limited, after a laborious series of trials and experiments on the matter, lasting over several years. The earliest patent relating to the production of these substances was taken out as far back as 1868, by the late Dr. John Scoffern, while laboratory-made specimens, and models, etc., were exhibited in the Exhibition at South Kensington, 1872 (Scientific Inventions Department). Owing to the promising nature of the results obtained at this time, Mr. A. E. Healey, the present managing director of the company, selected a site at Willesden, and started the process in an experimental way in 1873; but numerous practical difficulties were encountered, and many modifications of the first machines employed were tried before the present arrangements were arrived at, enabling layers of material to be rolled 4 feet 6 inches wide, and of any required continuous length, without ruckle, flaw, or inequality. After the expenditure of much labor and patience, during some five years, a considerable measure of success in this direction was attained, so that in the Paris Exhibition of 1878 some fairly well-made rolls were shown with other specimens, for which three prizes were awarded; and since this date, numerous further improvements have been made, both in the nature of the plant and machinery requisite for the carrying on the manufacture, and in the preparation of the cupro-ammonium solution forming the starting point of the process;* so that it is only within a very recent period that the manufacture has actually attained to such a condition of completeness and perfection as to enable the products to be put in the market on any considerable scale, and that it has been practicable to produce in almost any required quantity such well made and useful products as those of which I am enabled to-night to show you specimens, through the kindness of the directors of the Willesden Company.

In the trade, these products are now known as "Willesden" goods, and are divisible into two classes, viz., (*a*) the round or made-up goods, such as Willesden rope and cordage, Willesden netting, etc., and (*b*) the rolled or flat goods turned out in roll at the Willesden Mills.

Goods of the first class (*a*) are prepared by simply dipping the made-up materials to be treated into a bath of cupro-ammonium solution, using certain precautions as to the mode of immersion and its duration, and the strength of the solution. On subsequently drying the dipped fabrics, they are obtained coated and impregnated with cupro-cellulose, which thus not merely forms a kind of varnish-like surface dressing, but further adds strength to the fibers by more or less intimately cementing them together. The freedom from liability to mildew and rot of these products is remarkable, while they possess many advantages as compared with similar goods protected by tarring, or dipping in the bark vat, or treatment with other preservative compositions.

Goods of the second class (*b*) constitute a much more important group, to which at present the Willesden Company more especially devotes its attention. These fabrics are essentially of three kinds, viz., Willesden Canvas, Willesden Scrim, and Willesden Paper. The former two of these classes possess many features in common with the round or made-up goods just described, being prepared in much the same way, saving that the fabric to be treated is usually unwound from one roller and rewound upon another, after passing successively through the bath and a succession of drying rolls somewhat analogous to those of a paper mill. Like Willesden cordage and netting, they exhibit remarkable freedom from moulding and mildewing influences. This point is well exemplified by the illustrations exhibited.

(Specimens were here shown of strips of canvas, and scrim of various kinds, kept partly immersed in water in loosely covered jars for periods varying from a few weeks to about four months; in each case a strip of original untreated fabric and one of the same substance after "Willesdenizing" being side by side. The untreated specimens were copiously mildewed to extents varying with their age from just perceptibly incipient growth to completely developed large fungoid masses. The "Willesdenized" samples were just as perfect and free from mildew as when first put in.)

Willesden Paper.—This manufacture may be subdivided into two departments, viz., (1) Willesden unwelded, (2) Willesden welded (rolled goods), the first class being a single web or ply of paper of indefinite length passed through the bath, and rolled and dried in much the same way as canvas and scrim; the second class consisting of more than one ply or layer of primary material, incorporated into one solid insoluble sheet or homogeneous panel of indefinite continuous length.

1. Unwelded or "one-ply" paper exhibits much the same general resistance to mildewing and moulding influences as Willesden canvas and cordage, etc. According to the nature of the paper originally treated, different kinds of Willesden 1-ply (W.P.G. 1) result. Certain coarse varieties furnish a waterproof material excellently adapted for lining packages, and wrapping parcels, etc., liable to be exposed to damp during transit, and of special value as a first coat of paper to be applied to damp walls. Finer qualities furnish envelopes and stationery possessing the valuable property of not being affected by water. Letters written with such stationery would be as legible as ever (provided the ink were not washed away or bleached) even if the mail-bags containing them were sunk in the ocean or washed overboard, and not recovered until after long periods of immersion. In connection with this may be noticed a mode of fastening envelopes, affording security against opening and tampering with contents, impossible with ordinary gummed envelopes, or with those secured by sealing wax, either of which, as is well known, can be readily opened by a skilled person, and reclosed without noticeable alteration (an impression of the seal being of course taken in the case of sealed letters, and subsequently used to reseal them). This method consists in using as fastening material a concentrated cupro-ammonium solution; the edges of the envelope are moistened therewith, whereby the paper is gelatinized; the envelope is then closed and ironed with a warm flat iron, when the gelatinized cellulose is converted into an insoluble cupro-cellulose, and the cover is fastened down so securely that the only possible mode of opening is to tear the paper. No amount of steaming or treatment with water will undo the cement, as it would with a gummed envelope. Another application of this same principle consists in the use of a wafer of "Willisdenized" paper, moistened with cupro-ammonium solution before use. Obviously, the same principle may be applied in the direction of cementing together the edges of sheets of paper so as to form larger sheets, fixing firmly together paper, pasteboard, wood, and analogous surfaces, bookbinding, and in numerous other ways; troughs and dishes, watertight boxes and packing case linings, etc., are readily prepared thus.

(Samples of the same kinds of paper before and after treatment, immersed in water for various periods, side by side, were here exhibited, the former being more or less completely softened and pulped, while the latter indicated no change whatever; practical illustrations of the effect of a few minutes' boiling in water on the different specimens were also given, the treated specimens being unaffected, while the untreated ones were more or less completely softened and disintegrated.)

2 Welded Willesden goods have undoubtedly the merit of being the most remarkable and interesting of all, on account of their novelty and important applications; they are all prepared in substantially the same way, viz., by simultaneously dipping more than one ply, and pressing into one compact, homogeneous sheet the various layers, while still gelatinized or pectized by the action of the cupro-ammonium solution. According to the nature and thickness of the finished material, various subdivisions of this class may be tabulated, *e. g.*:

W.P.G. 8. Willesden 8-ply; panel board.

W.P.G. 4. Willesden 4-ply; for roofing, building, paneling, decorating, etc.

W.P.G. 2. Willesden 2-ply; for underlining, interior decoration, floors, damp walls, packing, leaky roofs, etc.

W.P.G. 1. Willesden 1-ply; described above as unwelded Willesden goods.

Besides these, various kinds of combination fabrics may be noticed, such as those obtainable by simultaneously treating paper and calico, and welding the two together so as to form an article resembling ordinary mounted drawing paper, but differing therefrom in the important character that long continued immersion and even long boiling in water causes not the least disintegration or separation of the two diverse fabrics thus combined; so that military and submarine engineers' and surveyors' plans, and the like, drawn on such paper would be uninjured by being exposed to wet and rain, if the colors or ink were of suitable kinds, so as to resist the action of the water.

Willesden 8-Ply.—This material is adapted for panel work and use where great strength is required, and is valuable owing to its being made (to special order) 54 or even 60 inches wide, and in continuous lengths; from the nature of this material there is no fear of its cracking or splitting like ordinary panel board. For boat-building and naval construction generally it is well adapted. (Specimen shown of 8-ply panel boiled under 60 lb. pressure for eight consecutive weeks in one of the steam boilers at the Willesden factory, without undergoing any disintegration, or serious change of any kind beyond a slight cockling.)

Willesden 4-Ply.—Next to slates and tiles, this material stands pre-eminent as a durable roofing material, unassailable by weather of all kinds; while its strength, combined with lightness and flexibility, combine to render it a most valuable and unique article for practical use and service; more especially are these advantages manifest in connection with up-country and foreign employments. Mr. Healey furnishes me with the following statement, comparing the relative weights and covering powers of W.P.G. 4 and good galvanized iron:

Weight of One Square (100 Square Feet) in Pounds.

W.P.G. 4.	Galvanized Iron.
15 to 18.	103 to 280.

Area Covered by One Ton.

800 to 2,170 square feet, or 8 to 22 squares.	12,500 to 15,000 square feet, or 125 to 150 squares.

It is hence abundantly manifested that Willesden 4-ply would come far cheaper than galvanized iron, in any district where the cost of transit is heavy, more especially in new districts, where the means of communication with the sea board are but imperfectly opened up. Again, being put up in compact rolls (ordinarily of 2 cwt. each), no space is wasted in packing. Another special advantage is, that being comparatively non-conducting, the heat of a tropical sum is less felt under a roof of this kind than under a metallic one; while, on the other hand, the condensation of moisture from warm air inside a hut thus roofed or walled is all but imperceptible, even on a cold night; whereas an iron building, under similar conditions, frequently gives an inconvenient drip of condensed water from the roof, and small streams running down the walls.

For building purposes generally, and interior use, W.P.G. 4 offers many advantages. Where the buildings are temporary and intended for subsequent removal elsewhere (*e. g.*, workmen's huts when engaged in railroad construction, etc.), the lightness of this material renders it eminently adapted for construction in removable sections; and for more permanent structures it is equally advantageous for numerous reasons. It does not harbor moths or other vermin; in the hottest weather, under a boiling tropical sun, it remains unchanged, and emits no unpleasant odor; it requires no painting, and exempts from the necessity of using pot and brush year after year to prevent corrosion, or to make a neat surface, or render water-tight, being weather-proof in itself. If required for internal decoration, however, it will take paint readily, and, indeed, forms an admirable foundation for the painter and decorator to work upon, in this respect having marked advantages over felt, with which material it has nothing in common, although the two can, if desired, be used in conjunction. In case of fire, although not absolutely inde-

* Of the various patents possessed by the Willesden Company, for successive improvements and modifications, the latest is that of Dr. Alder Wright, for improvements in the production of cupro-ammonium and other analogous metallic solutions, by means of which the manufacture of this essential fluid is greatly cheapened and facilitated.

structible, yet "Willesden" will not readily feed the flames, the copperizing and compacting process by which it is made rendering it far less inflammable than such substances as painted or tarred felt, or wooden shingling; its lightness moreover renders much less massive timbering requisite for the support of roofs, thus again diminishing the risk of damage by conflagration, there being actually less combustible matter about a building erected with this material than is necessary when the weight of a slated or tiled roof has to be supported. It is to be noticed that a special method of fixing walls and roofs of Willesden paper is recommended, illustrations of which are exhibited. Many such roofs are now standing in perfectly good condition, after upward of eight years' exposure to weather of all sorts; similarly, pipes conveying both water and steam, such as those exhibited, have been in use upward of three years below ground at the Willesden Works, without any visible deterioration. (A number of experiments were here shown, and others described, illustrating the comparative effect of dry heat and of boiling water on W.P.G. 4, and on mackintosh, pitch papers, felt, tarpaulin, asphalt, Manchester packing, etc.; the former being unaffected, and the others rendered more or less unserviceable, and, in many instances, utterly spoiled.)

Willesden 2-Ply.—This material is susceptible of being used for many purposes for which 4-ply is applicable, more especially when a less degree of body and substance will suffice. One special purpose to which it is excellently well adapted, is for laying upon or under floorboard, upon joists, etc., to avoid damp and draughts. Used as a floor-cloth for stairs, offices, etc., it wears well and is most effective, the cost being only a fraction of that of linoleum, kamptulicon, and similar articles.

In conclusion, I am enabled, by the kindness of the Directors, to exhibit not merely the numerous examples of Willesden goods, and their applications surrounding us, but also a series of lime-light enlargements of photographs of buildings and other structures of magnitude, erected of Willesden paper.

Dr. Alder Wright, in reply to various questions, said he had heard from various sources that white ants and other vermin would not touch the Willesden material, owing to the presence of the copper, so that, if the copper could be removed, as one speaker had suggested, the safety of the material in this respect would be gone. Boats had been made of the paper, and they answered very well in fresh water, but he could not say whether they had been tested in salt water. One advantage in making boats of the paper was that they were lighter than those made of wood, and in the next place, they were very easily repaired. Photographic dishes could easily be made by taking a sheet and pinching up the corner, bulging being prevented by running a thread through the corners. These dishes could be used for chemicals, though it was not advisable to put in a second chemical if the first had remained in the dish for some time. As to the action of acids upon the card, that depended upon the concentration as well as the nature of the acid and the temperature. If the card were boiled in a beaker, with weak sulphuric or hydrochloric acid, beyond doubt copper in solution would be found, and, no doubt, there would be less copper in the card than there was before; but, in the cold, very little copper was dissolved out. He did not think that the solution of copper in this way would affect the stability of the material for such purposes as had been alluded to, more particularly in the use of galvanic cells. As to whether this material could be used for vats for bleaching purposes, that was a matter which experience alone could decide, though there was nothing in the character of the material which would unfit it for the purpose. At the same time, he was not prepared to assert that oil of vitriol could be kept in a vessel made of Willesden paper. With regard to the ropes being only superficially tinged with the coppery material, that partly arose from the circumstance that the rope had purposely not been immersed sufficiently long to enable the fluid to penetrate deeply. As the action of the solution was to dissolve and disintegrate fibers, if thin ropes were saturated all through they were apt to lose a certain amount of strength. It was not necessary that a rope should be saturated throughout. As to the paper treated at Willesden, complete penetration of the fluid into each ply of paper was a necessity, in order to obtain a proper product. The principal difficulty in carrying out the process consisted in exactly regulating the strength of the solution as regarded the amount of copper and ammonia, the nature of the paper, and the length of time during which it had to pass through the vat, in order that the solution should pass into the interior of the paper to the proper extent and no more; for if the action of solution was overdone, the material became too soft and tender to be dealt with by the machine. As to the paper being used as a medium for painting, he might say that both the canvas and paper were susceptible of use in this direction, though he was unable to speak with certainty as to canvas, owing to its not having been long in use; but there was every reason to believe that works of art on canvas treated by this process would be less subject to deterioration through injury to the foundation. He was not aware that the paper would have any effect upon any mineral color employed for decorative purposes. The action of copper upon certain organic dyes was well known, but these substances were rarely used for painting. The paper could be moulded into any shape, though this particular branch of the business had not yet been pushed, as the manufacture of the rolls appeared more promising. The production of thick plates for backing of armor plating was contemplated, and could be carried out by the action of the cupro-ammonium, either from paper pulp or cutting upon a mass which could be moulded into shape. As to the analogy between this paper and paper parchmentized with sulphuric acid, he might say the two processes were dissimilar, though chemically the change produced on the paper fiber was of much the same character. There was a certain amount of analogy between the processes; if, for example, a sheet of writing paper were impregnated with cupro-ammonium to a certain extent, it had much the same texture when finished as parchmentized paper, and microscopically there was the same kind of structure. The quantity of copper left in the paper after treatment would vary very much according to the length of time the paper was allowed to remain in the solution, and the quantity taken up, but in round figures an analysis of 4-ply paper showed that it contained about 4 per cent. of metal. Among other uses to which the paper might be put, was for covering bricks in the brickfield, and for making shelters for vineries. Upon the question of whether Willesden paper was a non-conductor for electricity or not, he thought, if the material was rolled up into a pipe and used for telegraph cables, it would serve very efficiently, though he doubted whether it would be used with advantage as a substitute for gutta-percha. It certainly did not conduct electricity readily; but as it contained copper, if there happened to be a leaky wire, reduction of metallic copper might be caused, whereby metallic communication would be set up from the wire to the earth, and, therefore, he doubted whether the substance could serve for the purpose of insulation. For chemical laboratories and household matters, there were a considerable number of applications where the material would come in most handily.

CHARLES ADOLPHE WURTZ.

Charles Adolphe Wurtz, the eminent chemist, died on the 12th of May, after a sickness of very short duration. Mr Wurtz was born on the 26th of November, 1817, at Wolfisheim, near Strassburg. His father was a Protestant clergyman of distinction, who reared his son with tenderness and instilled into him those exalted principles that are rarely forgotten when received in childhood—the sentiment of duty and honor, love of work, and the worship of family and country. After attending school at the Protestant Faculty of Theology, Wurtz, influenced by the example of his friend Kopp, applied himself to the study of chemistry and medicine. His first preceptor was Prof. A. Cailliot, of the Strassburg Faculty of Medicine, who, deprived of his chair by the events of 1870, afterward went to work in the laboratory of his distinguished pupil.

Having been made a doctor in 1843, he went to Paris the succeeding year, and there made some remarkable discoveries that attracted Dumas' attention to him. In 1846 he was appointed director of the chemical works at the Central School, and, in the following year, fellow of the Faculty of Medicine. In 1851 he was made professor at the Versailles Agricultural Institute. In 1853, the chairs of chemistry at the Faculty of Medicine occupied by Dumas and Orfila having been united, Wurtz was appointed to succeed those two masters of the science. Here he lectured for twenty-seven years, acting for ten years of this period as Dean of the Faculty. Elected member of the Academy of Medicine in 1856,

CHARLES ADOLPHE WURTZ.

he obtained that same year the great biennial prize of 20,000 francs for his labors in chemistry. In 1875 he was made a professor at the Sorbonne, where a special chair of organic chemistry had been created for him. In 1878 he had the honor to receive the Faraday medal from the Royal Society of London.

Three great discoveries especially mark the scientific work of Mr. Wurtz, and have made known bodies belonging to new families: *Compound ammonias, glycols, and aldols.*

Compound ammonias, or *amines*, as their name indicates, represent ammonia modified by the introduction of organic radicals. They preserve the fundamental character of ammonia, that of uniting directly with acids and forming true salts. The discovery of these has permitted of a classification of a host of bodies scattered through the science of chemistry; in the first place, for example, aniline, which has become one of the most interesting of substances, from the brilliant coloring matters that it yields; and, on another hand, the natural alkaloids, which are so useful to medicine, and which are nothing more than complex amines.

The history of the glycols is intimately connected with that of the plurivalent alcohols. Between glycerine, characterized as a trivalent alcohol, and ordinary univalent alcohol there ought to exist an intermediate one—a bivalent alcohol. This theoretic view, submitted in 1856 to the test of experiment, led to the discovery of glycol and its congeners. From glycol is derived oxide of ethylene, which is comparable in its properties to lime, and serves, so to speak, as a bond of union between organic and inorganic chemistry. The third great work, upon *aldol*, is of more recent date, and has occupied the twelve last years of Mr. Wurtz's life. In studying aldehyde, he discovered a polymere of this body that contained, condensed in one molecule, the matter contained in two molecules of aldehyde. This was *aldol*, the result of a true synthesis, since there was here the formation of a compound of a higher order in the series. This is a property common to all the aldehydes. Mr. Wurtz, in making known the law of these polymerisms, has shown the analogy that exists between these reactions and those that occur in the green parts of plants when, with the aid of solar radiation, carbonic acid is decomposed into carbon that accumulates in the form of vegetable matter, and into oxygen that is restored to the atmosphere. A host of other subjects have absorbed Mr. Wurtz's attention for the last forty years, and an enumeration alone of the titles of his memoirs would fill several columns. No problem that Mr. Wurtz ever took up was left unsolved by him. In addition to his memoirs, he was the author of many works that are characterized by their clearness and elegance of style. The principal of them are the following: *Traité de Chimie Medicale* (2 vols.); *Lecons Elementaires de Chimie Moderne; Traite de Chimie Biologique; Lecons de Philosophie Chimique; La Theorie Atomique; Histoire des Doctrines Chimiques depuis Lavoisier jusqu'a nos Jours*; and *Dictionnaire de Chimie Pure et Appliquee* (5 vols.).—*La Nature.*

[Nature.]

ON THE FORMATION OF STARCH IN LEAVES.

In a recent communication to the *Arbeiten des botanisches Institut* in Wurzburg (Bd. iii.), Prof. Sachs gives the results of his work during the past summer in connection with the above subject. The investigations were made with the object of determining the formation and disappearance of starch in the leaves of plants growing in the open, and under normal conditions of vegetation, and were carried on chiefly during the months of June, July, and August on a large number of dicotyledons from various families. Some twenty-two years ago Prof. Sachs showed that the presence of starch in chlorophyl grains can readily be detected by means of the now well-known iodine test, a modification of which was employed in these researches.

If fresh green leaves are plunged into boiling water for ten minutes or so, certain soluble substances are extracted, but the starch and coloring matter of the chlorophyl grains remain in the still unbroken cells of the mesophyl. A short immersion in alcohol now removes the green coloring matter and certain bodies soluble in alcohol, leaving the starch behind in the colorless tissue. The presence of acids affects the degree of whiteness of the decolorized leaf; and the decolorization proceeds more rapidly in sunlight or warm alcohol than in the dark and cold. Leaves of *Tropæolum* may be rendered completely white, like writing paper, in two or three minutes.

If the decolorized leaf be now placed in a strong solution of iodine in alcohol, the presence or absence of starch may be demonstrated in a few minutes. If no starch is present, the cellular tissue simply presents the well-known yellow color; if a large quantity of starch exists in the cells, the tissue appears blue-black, the venation appearing as a pale network in the dark ground. Paler colors result if but little starch is present at the time of the experiment.

It will readily be seen how useful the above method is for the purpose of demonstrating the absence of starch from etiolated leaves, the white portions of variegated foliage, etc., and the sequel shows that the method affords means of obtaining far more delicate results, without the trouble of a microscopic examination.

In the first place, the same leaf may be found to contain very different quantities of starch at different periods of the day, or according to the weather; and secondly, the increase and decrease of the quantities of starch in a given leaf may be very rapid.

Sachs showed long ago that if a plant is placed in the dark, the starch disappears from the leaves; and it has also been known for some time that if a piece of tinfoil is placed on a leaf, the covered portion forms no starch, although the parts exposed to light may become filled with that substance. Moreover, Kraus showed how very rapidly starch can be formed in direct sunlight.

Sachs now demonstrates on a number of plants that the

starch formed in the leaves during the day may disappear completely during the night, and that the leaves shown to be full of starch in the evening may be quite empty of starch next morning. This depends upon the temperature and health of the plant, but occurs normally during the summer in plants growing in the open. A large number of experiments are given in support of this, and showing how the rapidity and completion of the process depend upon the weather.

The experimental proof is very simple. A leaf is halved longitudinally at night, after a fine, sunny day, and the excised half is shown to be filled with starch by the iodine test described; the remaining half is tested early next morning, and shows at once if any material diminution has occurred during the night. A simple and obvious modification of this experiment gives an idea of the quantity of starch formed between surise and sunset.

The half leaf tested between sunrise shows no trace of starch; the other half, left on the plant during the day, is found to become more and more filled with starch toward the afternoon.

Some curious results were arrived at as to the effect of growing parts on the rapidity of the emptying of the leaves; some of these matters still require investigation.

Differences in the weight of leaves and in the intensity of the color produced by the iodine test, as well as some other observations, lead to a better understanding of a fact already known generally, viz., that the starch disappears from the leaves in the form of glucoses, which travel by way of the vascular bundles into the stems, and thus pass to the places where they are used up in growth.

Some very telling observations were made in this connection, and the dependence of the processes on temperature again show forth clearly.

These results lead to the conclusion that the process of metamorphosis into glucoses and translocation of the products of assimilation are also going on during daylight, though they are less evident, because more starch is then being formed and accumulated than is abstracted at the time. Moll proved that such is the case by exposing leaves to the sunlight, but in an atmosphere devoid of carbon dioxide; the starch already in the leaves disappeared, and no more was formed to replace it. Sachs repeated Moll's experiments, and proved the correctness of his conclusions by means of the iodine test. Half leaves were shown to be full of starch; the companion halves were put into closed atmospheres, deprived of carbon dioxide by means of potassium hydrate, and exposed to sunlight. In an hour the latter halves were tested, and found to be nearly emptied of starch. Other experiments proved that depletion occurred in a few hours, the time depending on the temperature.

Further experiments demonstrate that the starch travels in the form of glucoses in all the above cases; but it is not proved whether the metamorphosis is effected by forces in the chlorophyl grains themselves, or by means of diastatic ferments in the cells of the leaf. A few hints are here given showing a field for further research.

Perhaps the most ingenious part of the paper is that which now follows. It is well known that Weber's patient and thorough researches on the energy of assimilation led to two important results, among others: (1) that the quantity of starch formed by a certain area of leaf-surface in a certain time may be relatively very large; and (2) that different plants probably differ specifically as to the quantities of starch formed in their leaves.

Sachs proposes to apply his method to the solution of this question, *i. e.*, how much starch is produced in, say, one square meter of leaf-surface by assimilation during, say, ten hours' bright sunlight? The great difficulties in Weber's researches were connected with the enormous labor necessary to measure the leaf-surface accurately.

Sachs resolved the matter in a manner which we may summarize thus: He cut off portions of large leaves found to be empty of starch, measured them rapidly by laying them on pieces of board cut to the size of one square meter, and killed, dried, and weighed the measured portions very rapidly. Certain precautions as to the area of fibro-vascular bundles, the possibilities of absorbing hygroscopic moisture, etc., may here be passed over. Supposing these portions of the leaves to be estimated in the morning, a quantity of the same leaves of equal area gathered in the evening was then compared, and the increase in weight gives the quantity of starch formed in the interval. By weighing large areas, and frequently, and by paying attention to the times and other circumstances, a large number of results were obtained, showing that the quantities given by Weber, for instance, are within the mark. Of course these results are not absolute. Starch is being changed into glucose, and passing away during the day, and some must be burnt off in respiration; moreover, a certain minute quantity of mineral ash should be allowed for. Of course, it is an asumption that equal areas of mesophyl of the same leaves contain approximately the same amount of substance; nevertheless, if a large number of experiments are made, the error is probably small.

Experiments were made to show both the quantities of starch which disappear during the night and the quantities formed during the day. A few of the numbers may be given. In *Helianthus*, 9·64 grms. of starch disappeared in ten hours from one square meter of leaf surface.

In the same plant 9·14 grms. were formed in the same time by the same area of leaf surface.

In another case *Helianthus* was used, but the leaves were moved from the stem to prevent the passage back of the starch from the mesophyl into the stems.

A square meter was found to produce starch at the rate of 1·648 grms. per hour.

By combining his experimental results and taking note of all the circumstances, Sachs concludes that twenty to twenty-five grms. of starch per day may be produced by one square meter of leaf surface as an ordinary occurrence; and these numbers are not only not excessive, but experiments show that there are plants which produce much more than those investigated here.

Some remarkably interesting and important results follow from the consideration of these experimental data.

They explain why plants are so vigorous during warm nights following upon hot, bright days. The more readily the products of assimilation (formed in large quantities during the day) can pass into the growing organs, the better these are nourished, and so forth.

Leaves used for fodder, etc., must differ in nutritive value to a very great extent if their starchy contents vary so largely during the day and night; it thus becomes of primary importance whether such leaves are gathered in the morning or the evening, in cold or warm weather, etc. The same applies to *tobacco* and *tea*, etc. It must make a vast difference to the smoker whether his tobacco abounds in carbohydrates or is relatively richer in the alkaloids. It appears that tobacco is habitually cropped in the morning in some countries, a fact which suggests that experience has already shown that a difference in the quality exists; it will be interesting to inquire further into these matters.

Sachs' results will also materially affect the physiological value of the analyses of leaves. Some of us know how great are the variations met with analyses of the ash contents of leaves of the same plant. It is clear that, in addition to the age of the leaf, the soil, manure, etc., it is important to know the amount of starch present. It cannot but happen that the mineral matters ebb and flow as well as the starch. The analyses of leaves will also be more valuable for the purpose of physiology if the numbers are stated, not in simple percentages, but in terms of one square meter of the leaf surface.

The above brief summary of the results obtained by Prof. Sachs by no means does justice to the beauty of his methods and the masterly way in which they were carried out; it must be admitted by all who understand the value and importance of this work that it is worthy of the great pioneer of vegetable physiology. Moreover, it suggests several matters which require further investigation, and would no doubt yield valuable results to those fortunate enough to have a botanical garden at hand.

H. MARSHALL WARD.

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DETECTION OF SMALL QUANTITIES OF WATER ADDED TO MILK.

IT is an exceedingly simple matter for a chemist to determine the exact quantity of water in milk; but since all milk contains a very large quantity of water, and that a varying quantity, the chief dfficulty has been in distinguishing between the water naturally there and the water added fraudulently. Uffelmann attempts to solve this problem by looking for those substances which are always present in well water and never in pure milk, such as ammonia, and nitrous and nitric acids. For this purpose he first precipitates the caseine from 350 c. c. of milk, with dilute acetic acid, and filters it out. He then adds three drops of hydrochloric acid to the first filtrate, *a*, heats to boiling, and when cold filters it. Fifty c. c. of this second filtrate, *b*, is rendered slightly alkaline with caustic potash, filtered, and the last filtrate, *c*, is distilled. The distillate is tested for ammonia with Nessler's solution. Another fifty c. c. of above filtrate, *d*, is tested directly for ammonia (after adding caustic soda in a solution of the pure carbonate), with the same reagent. In this way the author succeeded in detecting 0·007 milligram of ammonia.

About 150 c. c. of filtrate *a* is boiled and filtered. Each 30 c. c. of filtrate is tested for nitrites with diamido benzol and with iodide of cadmium and starch. The remainder is tested for nitrates as follows: A piece of diphenylamine as large as a lentil is put in a white porcelain dish and dissolved in 1½ c. c. concentrated sulphuric acid, and three or four drops of filtrate *a* run into it. If nitric acid is present, the blue streaks will appear sooner or later, according as there are more or less nitrates present. If it does not make its appearance at all, the filtrate, *a*, is evaporated to one-third of its volume, filtered, and tested again in the same manner.

If the results are still negative, it is again evaporated and tested.

If the tests show the pressure of all three, nitrous and nitric acids and ammonia, it is proof that water has been added; but if the tests give negative results, it is not proof positive that no water has been added.

When water has been added, these tests give no indication of the amount added unless the quality of the water is likewise known, but it does prove that it is adulterated.—*Berichte.*

SEPARATION OF TIN, ANTIMONY, AND ARSENIC.

By EMIL BERGLUND.

THE author remarks that the present methods for the separation of these metals are either inaccurate or tedious. He proposes a process based on the fact that the sulphides of the three metals when boiled with copper oxide in an alkaline solution are desulphurized and converted into oxygen compounds. The three elements are brought to their highest stage of oxidation, being transformed respectively into stannic, antimonic, and arsenic acids, while the copper forms not cuprous but cupric sulphide.

Copper oxide acts with especial ease upon the dissolved sulphur compounds, the denser varieties more slowly than the less compact, but as the latter give a very voluminous precipitate, the author prefers the former. He precipitates a solution of copper with sodium carbonate, and dries the oxide at 100° to 150°. By preference, however, he prepares his oxide from the nitrate as follows: The solution of copper nitrate is evaporated to dryness in a small porcelain capsule, and heated to incipient decomposition. The mass is let cool, pulverized, and transferred to a porcelain capsule as small as possible, supported on a wire gauze, and heated, with constant stirring, until all the nitrate is decomposed. The heat must not be stronger than is absolutely necessary. The oxide thus obtained is reduced to an impalpable powder.

This copper oxide is readily sulphurized, and yields a very dense precipitate, easy to filter. The sulphides of tin, antimony, and arsenic must be dissolved in sodium sulphide, not in the hydrate.

The procedure is as follows: The sulphides, dissolved in the ordinary manner in ammonia, and precipitated by hydrochloric acid, are well washed, and rinsed from the filter into a porcelain capsule. The mixture is raised to a boil; sodium sulphide (avoiding large excess) is added cautiously, stirring constantly, and keeping up a gentle boil until a perfectly clear solution is obtained, or the analyst is convinced that any dark brown residue is merely copper sulphide which has been dissolved by the ammonium sulphide from the original precipitate given by sulphureted hydrogen. Disregarding this copper sulphide, if present, copper oxide is added, and the stirring and ebullition are continued. It is easy to decide when the desulphurization is complete; the copper oxide subsides as a very heavy powder, and the supernatant liquid becomes quite colorless, not yellow as previously. If this change does not occur in the course of two or three minutes, more copper oxide must be added, though it is preferable to take a sufficiency at first.

The liquid is filtered while still warm. In the filtrate tin, antimony, and arsenic exist as sodium stannate, antimoniate, and arseniate. If the proportion of antimony is considerable, there is formed a white granular precipitate as the filtrate cools. When cold the filtrate is mixed with from a quarter to one-third its volume of alcohol, when the antimony separates out as an exceedingly fine white precipitate, and after standing for some time it is filtered off; if the filtrate is turbid, as is generally the case, it is repeatedly poured back upon the filter. The filtrate, when clear, is boiled to expel the alcohol, and mixed with an excess of ammonium chloride, which is added in a strong solution to prevent unnecessary dilution.

If a milky precipitate is formed on adding the sal-ammoniac, tin is present in the solution; but if no precipitate is formed, this metal exists in more traces If arsenic is present, it enters partially or entirely into the precipitate in the form of $2SnO_2As_2O_5$. Whether the sal-ammoniac produces a precipitate or not a few drops of ammonia are added, and a current of sulphureted hydrogen is passed in. If no precipitate appears, very little sulphureted hydrogen is applied; otherwise this treatment is continued until the precipitate redissolves, leaving, possibly, some translucent flakes of silica and alumina. To the liquid, filtered if necessary, is added one-third of its volume of ammonia, and then magnesia mixture, when arsenic is deposited as a crystalline precipitate of ammonio-magnesium arseniate. If the presence of tin has not been distinctly proved, the arsenical precipitate is filtered off after the lapse of an hour, and the filtrate acidulated with hydrochloric acid. A yellow precipitate shows the presence of tin; in its absence there appears merely a slight white deposit of sulphur.

The above method for separating tin and arsenic is a modification of that of Lenssen. The authors purpose studying the applicability of his process to quantitative separations of the three metals.—*Berichte Deutsch. Chem. Gesellschaft.*

REMINISCENCES OF MORSE'S TELEGRAPH LINE FROM BALTIMORE TO WASHINGTON.

THE near completion of the laying of the first of the Commercial Company's cable from Valentia to Dover Bay, calls to mind some interesting facts connected with the history of telegraph building in this country. Forty-one years ago, in the month of May, Professor Morse accomplished the aim of his life in having laid the first working telegraph line in America between Washington and Baltimore. On March 3, 1843, preceding this great event, Congress had passed a bill appropriating $30,000 for the construction of this experimental line. The debate on this question was sharp, and public opinion much divided. The resolution was finally passed, the vote standing at 90 yeas and 82 nays. New Hampshire, Georgia, Mississippi, Alabama, and Arkansas voted solidly against. New York stood 22 for, 11 against. The bill had yet to pass the Senate. Professor Morse was then at one of the darkest periods of his life. After paying his hotel bill at Washington and procuring a ticket for New York—for he despaired of the bill passing in the Senate—he had just 37½ c. left. On the day he was about to leave Washington, Miss Annie S. Ellsworth, the daughter of the Commissioner of Patents, was the first to announce to and congratulate Professor Morse on the final passage of his bill. The Professor replied: "Annie, you are the first to inform me, and now I make you a promise. When the line is completed, the first dispatch sent upon it from Washington to Baltimore shall be yours."

Mr. Morse at once turned his attention to the construction of the first telegraphic line in America; the government allowed him a salary of $2,500 per annum meanwhile. Alfred Vail took charge of the machinery, and Ezra Cornell superintended the construction. Mr. Morse at first adopted the underground method. He ordered forty miles of a fine wire cable in New York inclosed in a lead. A trench to lay it in was dug by a plow invented for the purpose. But seven miles of wire were thus laid from Baltimore to the Relay House. Mr. Morse found, to his great chagrin, that the method was unsuitable, but not till after half the appropriation had been spent. It was finally determined to lay the line on poles, with two copper wires, covered with cotton saturated with gum shellac. In May, 1844, the line was completed. The first office was at Washington, in the Capitol. The apparatus used on this first line was bulky and coarsely constructed. The relay magnets weighed 185 pounds. The coils were eighteen inches in diameter, of No. 16 copper wire, insulated with cotton thread. Mr Morse presided at the instrument in Washington, and Mr. Vail in Baltimore.

Miss Ellsworth was sent for by Mr. Morse and he requested her to frame the first message to be sent over the first wire. She sent this message: "What has God wrought?" It was successfully transmitted, and the strip of paper on which it was imprinted was claimed by Governor Seymour of Connecticut in honor of the lady, who was a native of his State, and of the inventor who had there received his college education. The first public message sent was by Vail to Morse. The occasion was the meeting of the National Convention at Baltimore to nominate a President. James K. Polk was nominated for the Presidency and Silas Wright for the Vice-Presidency. Mr. Morse conveyed the message to Wright, who was in Washington. Wright declined the nomination, and Morse telegraphed to that effect to Baltimore. It was a great surprise to the Convention to receive this news within a few minutes of their previous action. The body refused to believe the information authentic, and waited until a committee had been sent to Washington to confer with Wright. The committee confirmed the first message by a second one. Thus the telegraph received a great boom, and came prominently into public notice.

The new line was worked merely for exhibition until April 1, 1845, on which day it was opened for public business, and a rate of transmission fixed. The first operators under this rule were Mr. Vail at Washington and Mr. Henry J. Rogers at Baltimore. The tariff was fixed by the Postmaster-General at one cent for every four characters, under whose supervision the line was placed by Congress, which voted an appropriation of $8,000 to keep it in operation during the year. The receipts for the first four days of public operation were exactly one cent. This was the contribution of an officeseeker, who wanted to see the working of the wire for nothing at first, but who was informed it was impossible, as the operators were sworn to do paid duty. As the officeseeker had but a twenty dollar bill and a cent, so he said, it was arranged that he should invest in a cent's worth of electricity. Washington asked Baltimore "4," which signal meant "What time is it?" Baltimore replied "1," meaning one o'clock. As this message included only two characters, the officeseeker was entitled to a half cent in change. As the change was not forthcoming, the new line was a half cent ahead on the legal rates. On April 5 business was brisk; twelve and a half cents were received. On April 6, Sunday, no messages were sent. On April 7 there was a startling rise in the receipts—sixty cents. On April 8 the business was overwhelming—$1.82. This was too good to last. On April 9 the receipts dwindled to $1.04.

When the value of his invention had been fairly estab-

lished, Mr. Morse offered it to the government for $100,000. Upon adverse representations made by the Postmaster-General, the offer was refused. Mr. Morse then set to work to enlist private capital in the development of his invention. It was not an easy task. Men with money fought shy of the new undertaking. To stir the capitalists up, a short experimental line was laid in New York city from No. 112 Broadway to a house near the Metropolitan Hotel. It was with the utmost difficulty that permission was obtained to have the connecting wires strung along the tops of the houses, the owners fearing an increase of liability of their property being struck by lightning. Mr. Ezra Cornell, afterward the founder of Cornell University, had charge of this experiment. Fifteen thousand dollars were needed to construct a line from Fort Lee to Philadelphia, which was the first link of a projected line to Washington *via* Baltimore. This money was subscribed, Mr. Corcoran, of Washington, being the first contributor. The first telegraphic charter issued in the United States was granted by the Maryland Legislature. The first company was known as the "Magnetic Telegraph Company."—*Electrical Era.*

LIGHTNING CONDUCTORS.*

THE testing of lightning conductors should comprise—(1) that of the conductor, (2) that of the communication with the earth.

The testing of the conductivity of the conductor, which should have a very low electrical resistance, is very delicate, for it may happen that in consequence of oxidation, or from other reasons, the section of the conductor is reduced in some parts to very small dimensions, while the electrical tests show no appreciable diminution of conductivity. It is certain, moreover, as M. Helmholtz remarked at the last meeting of the *Congrès des Electriciens*, that the continuity of a conductor might be completely interrupted at one point without destroying the efficiency of the conductor as a preservative against lightning, while a fine wire connecting two distant parts of the principal conductor might present a perfect conductivity without offering sufficient capacity for the atmospheric electricity of a storm.

In any case there is no doubt that it is indispensable that the branches of a lightning conductor and their continuity be tested with care from time to time, as is done annually with the lightning conductors on military edifices. As for the frequent trials of continuity, these may be easily made by means of a battery and galvanometer, as will be shown further on.

The good communication with the earth, which is at least as important, can only be accurately measured by means of two other earth wires, completely independent of the first, and embedded in the soil at a distance sufficient to give perfect diffusion of the electric fluid at each point, and to prevent the passage of electricity directly through the earth which separates them. By means of three galvanometrical experiments we may have the sum of the resistances of these communications taken two by two, and deduce from it the value of each. If x, y, and z represent these resistances, a, b, and c the values found for the sums $x+y$, $x+z$, and $y+z$, we have:

$$x=\frac{a+b-c}{2},\ y=\frac{a+c-b}{2},\ z=\frac{b+c-a}{2}.$$

This experiment, which is very delicate, and in which we must take into account the polarization of the electrodes, evidently cannot be intrusted to inexperienced persons.

For the lightning conductors of Paris, for example, it is generally considered sufficient to plant in the earth, at a short distance from the lightning conductor, a metallic plate, with a surface one decimeter square, and to ascertain that the current passes when this plate is connected with the rod by introducing into the circuit a battery and a galvanometer. The resistance of the two earths thus measured is ordinarily very high; it often exceeds, it appears, 2 to 300 ohms, which is a very considerable figure, if we consider that in telegraph offices the resistance opposed to the current by the contact with the soil at each post does not reach, in general, 20 or 25 ohms. It seems necessary to fix a maximum for the resistance which we ought to take for the communication of lightning rods with the soil. This maximum seems capable of being fixed at 25 ohms; and when we determine the total resistance by taking two independent earth wires, we should not obtain a figure higher than 5 ohms.

For the measurement of this resistance the method which seems most simple and most practicable is that by a differential galvanometer.

The committee proposes, therefore, to establish in a fixed position in every building provided with a lightning rod, in addition to the principal earth contact, a second contact, completely independent of the first, and situated at 20, 30, or more meters from it, according to the nature of the soil and local conditions, which will be tested as to perfect efficiency, once for all, by a competent person. This second contact will be connected with a wire leading to the experimenting room, and may, moreover, be attached to the principal conductor when not required for making tests.

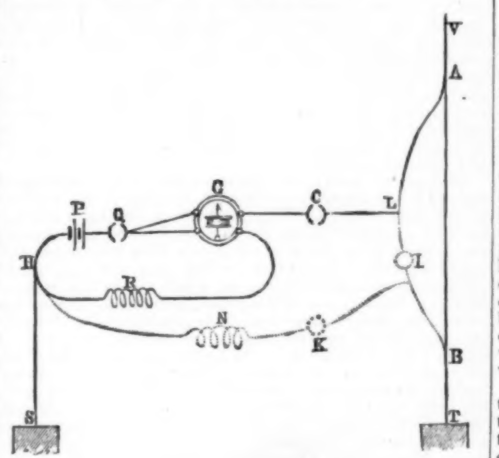
A wire covered with gutta percha would be carried off from an elevated part, A, of the lightning rod, and would lead to an interrupter, C, insulated in the normal state. This interrupter would allow of connecting at will, by means of a metallic plug, the lightning rod, A, B, with one of the circuits of a differential galvanometer, G. The other extremity of the same circuit would lead to a second interrupter, Q, in connection with a small battery, P, and with the second earth wire, S.

The second circuit of the differential galvanometer would be connected, on one hand, with the interrupter, Q, and on the other, at the point, H, with the auxiliary earth wire, H, S; a resistance, R, equal to that which should not be exceeded by the earth connection between H and T, or about 50 ohms, would be placed in this circuit.

To make the test, we would commence by closing the local circuit, by putting in the plug of the interrupter, Q, which would enable us to ascertain, by the deflection of the needle, whether the battery, P, is in good condition; then we should put in the plug of the second interrupter, C. The galvanometer needle should return to a state of repose, or even pass to the other side of the zero, if the resistance of the earth is lower than the resistance, R, or 50 ohms, that is to say, if the lightning conductor is in working order. If the deflection should not change in direction, it should be ascertained whether the conductivity of the portion of the rod, A, B, is interrupted, or whether the connections with the earth are defective, which would be the case if, for instance, one of them being formed of a plate, originally immersed in water, had become dry.

This examination should be intrusted to an experienced man, who should be warned by the attendant of the bad state of the connections; but the experiment could easily be carried further. It would be sufficient to have a second wire, L, B, establishing communication between the commutator, C, and the foot of the lightning rod, in which would be placed an interrupter, I, and to connect this wire with the point, H, by a conductor also provided with an interrupter, K.

In the normal condition the circuit would be closed by the plug of the interrupter, I, which would furnish a second connection, A, I, T, between the summit of the rod and the earth; to make the first trial, as was indicated above, it would suffice to remove the plug of the interrupter, I, and proceed as before. In order to insure the continuity of the lightning conductor, metallic plugs should be inserted in the three interrupters, K, C, and Q; the two circuits of the differential galvanometer being closed, the needle should remain at rest or deviate under the action of the current passing through the rod, if the resistance of the circuit, H, N, K, B, A, L, C, is below that of the rheostat, R. A resistance slightly below R, placed at N, would render this test still more exact, and would enable us to make sure that the rod of the lightning conductor and the auxiliary wires offer only an insignificant resistance, and are consequently in good condition. If it were found that the current which ought to pass through the lightning conductor does not do so, the fault could be discovered by arranging a conducting wire in communication, on the one hand, with the interrupter, K, the other extremity being connected with various points of the lightning conductor between B and A.



Lastly, if the principal conductor should be found by experiment to be in good condition, the secondary wire, H, S, should be tested as well, and also the communication with the earth. These tests present no difficulty, and require no complicated instrument, in order to obtain accuracy. The galvanometer may have the ordinary form of the galvanometers at telegraph stations; and as to the battery, it may consist simply of one or two Leclanche elements.

We have indicated 50 ohms as the limit of resistance between the two independent earths; perhaps it would be advisable, in each particular case, to examine whether this limit is sufficient, or if it would not be better to fix a somewhat different value. This value should depend on the more or less advantageous installation of the earth wires.

In order to avoid all danger, it is better that the commutators, C and K, which should be in readiness in the experimenting room, should have, on ordinary occasions, no communication with the lightning conductor, which might be effected by detaching the wires connecting them with the conductor, A, I, B, if the latter be external, or by cutting off, at A and B, the communication of the wire, A, I, B, with the lightning conductor. When there is telegraphic communication with a station situated at a certain distance, the establishment of a second earth wire, H, S, is useless. It is sufficient to connect the point, H, with the telegraph wire itself, placed directly in communication with the earth at its other extremity at the time of the experiment; but then the resistance, R, must be increased by a quantity equal to the resistance of this conductor.

* *Annales Telegraphiques*.—Extract from a Report of the Committee of Improvement of the Postal and Telegraphic Administration.—*Electrical Review.*

AN APPLICATION OF ELECTRICITY TO SURGERY.

WE borrow from one of the last numbers of the *Elektrotechnische Rundschau* a description of an apparatus constructed by the Electro dynamo Co., of Philadelphia, which will prove an advantageous substitute for the apparatus that have hitherto been employed in resections and trepanning. Resection is an operation that consists in removing an affected part of a bone. In this operation the surgeon holds the decayed parts with one hand and uses the surgical saw with the other.

The operation is not of the easiest character, and always necessitates the expenditure of considerable muscular strength, as may easily be imagined. The apparatus shown herewith is designed expressly to substitute mechanical force for muscular, so that the whole attention of the operator may be devoted to the delicate parts of the operation.

The instrument consists essentially of a metallic handle, to the center of which is screwed a small Griscom electric motor. To the left, and in the axis of this latter, there is mounted a circular saw. The upper half of the latter moves in the interior of a shield, so that the apparatus may be placed in any position whatever, without the operator's running any risk of having his hand wounded by the teeth of the saw

The apparatus is equally well adapted for trepanning, the circular saw in this case being merely replaced by a trepan one.

The electromotive force necessary may be obtained by means of six Trouve elements. The results of some experiments made by Dr. Th. Stein are of the most satisfactory nature, both as regards the accuracy and the rapidity with which operations may be performed. For example, it is found that with this instrument the very largest bones may be sawed through in thirty seconds, a result that could not possibly be obtained with the best instruments and most skillful hand by ordinary processes.—*La Lumiere Electrique.*

THE RELATIONS OF THE SOIL TO HEALTH.*

By GEORGE H. ROHE, M.D.

I.—THE SOIL.

THAT wisest and most learned of the ancients, Hippocrates, called the Father of Medicine, treated at length in one of his works of the sanitary influence of the soil. Others of the older writers, especially Herodotus and Galen, called attention to the same subject, and Vitruvius, the celebrated Roman architect, who flourished about the beginning of the Christian era, taught that a point of first importance in building a dwelling was to select a site upon a healthy soil.

From this time until the beginning of the eighteenth century, very little of value is found in medical literature bearing upon this subject. In 1717, however, Lancisi published his great work on the causes of malarial fevers, in which he laid the foundation for the modern theory of malaria and pointed out of the relations existing between marshes and low-lying lands and those diseases, by common consent, called malarial. Other authors of the eighteenth and the early part of the nineteenth century refer to the connection between the soil and disease, but exact investigations have only been made within the last thirty years. The general want of definite knowledge upon this subject, even among well-educated people, is the occasion of the following pages.

When we consider that the air we breathe, and much of the water we drink, are influenced in their composition by the matters in the soil, the great importance of possessing a thorough knowledge of the physical and chemical conditions of the soil becomes evident to every one.

In the hygienic, as in the geological sense, we include rock, sand, and gravel in the consideration of soils.

The soil, as it is presented to us at the surface of the earth, is the result of long ages of disintegration of the primitive rocks by the action of the elements, of the decomposition of organic remains, and possibly of accretions of cosmical dust. The principal factor, however, is the action of water upon rock, in leveling the projections of the earth's surface, produced by volcanic action.

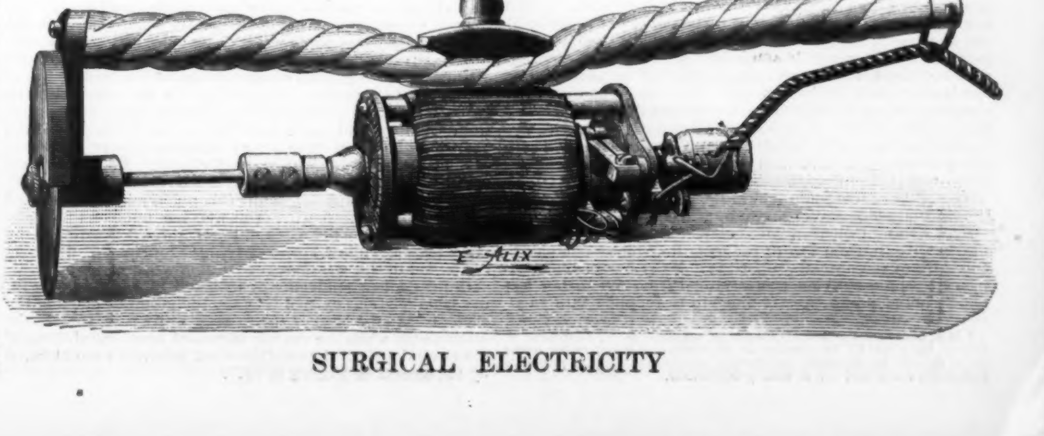
Soils vary considerably in physical and chemical constitution. We may have, for example, a soil consisting exclusively of sand, of clay, or of disintegrated calcareous matter Other soils may consist of a mixture of two or more of these, together with vegetable matter undergoing slow oxidation. In forests, we find a layer of this slowly decomposing vegetable matter of varying thickness covering the earthy substratum. This organic layer is called *humus*, and when turned under by plow or spade, and mixed with the sand or clay-base, it constitutes the ordinary agricultural soil.

II.—THE ATMOSPHERE OF THE SOIL, OR GROUND AIR.

The interstices of the soil are occupied by air or water, or by both together. The soil's atmosphere is continuous with and resembles in physical and chemical properties that which envelops the earth. Its proportion to the mass of the soil depends upon the degree of porosity of the soil and upon the amount of moisture present. In a very porous soil, such as for example a coarse sand, gravelly loam, or coarse grained sandstone, the amount of air is much greater than in a clayey soil, granite, or marble. So, likewise, when the soil contains a large proportion of water, the air is to this extent excluded. The porosity of various soils, as evidenced by the amount of air contained in them, is much greater than would, at first thought, be supposed. Thus it has been found that porous sandstone may contain as much as one-third of its bulk of air, while the proportion of air contained in sand, gravel, or loose soil may amount to from thirty to fifty per cent.

The ground air is simply the atmospheric air which had penetrated into the interstices of the soil and taken part in the various chemical decompositions going on there. In

* From the Third Annual Report of the State Board of Health of West Virginia.



SURGICAL ELECTRICITY

consequence of these chemical changes, the relative proportions of the oxygen and carbonic acid in the air are changed, oxygen disappearing and giving place to carbonic acid. It is well known that, during the decay of vegetable matter in the air, carbonic acid is formed; one constituent of this compound—the carbon—being derived from the vegetable matter while the oxygen is taken from the air. Hence, if this action takes place where there is not a very free circulation of air, as in the soil, the air there present soon loses its normal proportion of oxygen, which enters into combination with the carbon of the vegetable matter to form carbonic acid.

Thirty years ago, MM. Boussingault and Levy, two distinguished French chemists, examined the air contained in ordinary agricultural soil, and found that the oxygen was diminished to about one-half of the proportion nominally present in atmospheric air, while the carbonic acid was enormously increased. The exact results obtained by Boussingault and Levy were as follows:

In one hundred volumes of ground air there were 10·35 volumes of oxygen, 79·91 volumes of nitrogen, 9·74 volumes of carbonic acid. In atmospheric air, on the other hand, there are in one hundred volumes 20·9 volumes of oxygen, 79·1 volumes of nitrogen, 0·04 volume of carbonic acid, or about one twenty-fifth of one per cent. of carbonic acid.

In spite of the striking results obtained by these two chemists, very little attention was paid to them by sanitarians, as very few seemed to have any clear notion of the relations existing between the motions of the air above ground and that under ground.

In 1871, however, Prof. Von Pettenkofer, of Munich, whose authority in sanitary matters is second to none, published the results of his own examinations into the constitution and physical conditions of the ground air, and the relations of the latter to the propagation of epidemic diseases. These researches, which created a widespread interest in the subject, were extended by other observers in all parts of the world. These observers, prominent among whom were Professors Fleck and Fodor in Germany, Drs. Lewis and Cunningham in India, Prof. Wm. Ripley Nichols in Boston, and Surgeons J. H. Kidder and S. H. Griffith, of the U. S. Navy, in Washington, demonstrated that the increase of carbonic acid in the ground air is due to increased vegetable decomposition and to lessened permeability of the soil. A permeable, that is to say, a sandy or gravelly soil, is likely to contain less carbonic acid in its atmosphere than a dense, less permeable clay, although the amount of decomposition going on, and the production of carbonic acid in the former, may considerably exceed the latter. In the loose sandy soil the circulation of the air is less obstructed, and the carbonic acid may easily escape and be diffused in the superincumbent air, while the close-pored clay imprisons the carbonic acid and prevents or retards its escape into the air above.

The disappearance of oxygen from the ground atmosphere is coincident with the production of an equivalent amount of carbonic acid. It appears from this that in the soil an oxidation of carbonaceous substance takes place, the product of which is the excess of carbonic acid in the ground air.

Prof. Nichols has found the proportion of carbonic acid in the air taken from a depth of ten feet below the surface in the "made land" of Boston, amount to 21·21 per thousand, the observation being made in August. In December, at a depth of six feet, the proportion was 3·23 per thousand. Fodor, in Buda-Pesth, found the proportion of carbonic acid to be 107·5 per thousand (over 10 per cent.), the air being taken from a depth of thirteen feet.

Movements of the ground atmosphere are principally due to differences of pressure and temperature in the air above ground. Owing to such differences the air from the soil frequently permeates houses, entering from cellars or basements. In winter, when the air of houses is very much more heated (and consequently less dense) than the air out of doors, the difference of pressure, thus caused, draws the ground air up through the house, while the cold external atmosphere penetrates the soil and occupies the place of the displaced ground air.* A similar effect occurs in consequence of heavy rains. The water fills up the interstices of the soil near the surface, and forces the ground air out at points where the pores remain open. These places are the dry ground under buildings, where the air escapes and passes through floors and ceilings into the house above. Heavy rains may thus be the cause of pollution of the air in houses. The greater the porosity of the soil, the more likely is this to happen. This pollution of the house air may be prevented by having impervious floors and walls to cellars and basements, or by interposing a layer of charcoal between the ground and the floor of the house.

In the spring and early summer the ground being colder than the air above it, and the ground air consequently heavier and denser, the latter is not easily displaced. It is perhaps due to this fact that those infectious diseases which are probably dependent upon the movements of the ground air, are less prevalent in the spring and early summer than in the latter part of summer, autumn, and early winter. In the autumn, the ground air being warmer than the air above ground is easily displaced by the latter, and forced out into the streets and houses to be inspired by men and animals. The same conditions may explain the greater likelihood of infection at night, which is proved for such diseases as malarial and yellow fevers. The colder outside air penetrates the interstices of the soil, and forces out the impure ground air.

The researches of Fodor have demonstrated that the proportion of carbonic acid in the ground air may be taken as an approximative measure of the impurity of the soil whence the air is taken. The influence of the permeability of the soil, as before pointed out, must however not be overlooked in estimating the signification of the carbonic acid. Fodor has shown that the proportion of carbonic acid in the ground air, and consequently the amount of organic decomposition, is greatest in July and least in March. That the carbonic acid is derived from the decomposition of organic matter has been proved by Pettenkofer. This observer examined specimens of air brought from the Libyan desert, and found that the proportion of carbonic acid in the ground air was exactly the same as in the air collected above ground. There being no vegetable growth in the desert there can, of course, be no vegetable decomposition going on in the soil.

The excess of carbonic acid in the ground air is an indication of the deficiency of oxygen, as has been shown. The air at a depth of thirteen feet below the surface was found to contain only from 7 to 10 per cent. of oxygen—one-half to one-third of the normal proportion. Many basements occupied by people as living rooms extend from five to ten feet underground, and hence are liable to be supplied with an atmosphere approaching in impurity that just mentioned. It requires no very vivid imagination to appreciate the dangers to health that dwell in such habitations.

* It is, of course, not strictly correct to say that the air *is drawn* up through the house by the diminution of pressure; it being rather *forced* out of the soil by the colder and denser outside air; but the phrase is sufficiently exact and will be readily understood.

III.—THE WATER OF THE SOIL, OR GROUND WATER.

At a variable depth below the surface of the ground, a stratum of earth or rock is found through which water passes with difficulty, if at all. Above this, there is a stratum of water which moves from a higher to a lower level, and which varies in depth at different times according to the amount of precipitation (rain or snow-fall) and according to the level of the nearest body of water toward which it flows. This stratum of water is termed the *ground water*, and has within the last few years assumed considerable importance from its apparently close relations to the spread of certain of the infectious diseases. The direction of horizontal flow of the ground water is always toward the drainage area of the district. Thus, it is usually toward lakes, rivers, or the sea. Rains or a rise in the river cause a rise in the ground water, while long continued dry weather, or a low stage of the river, which drains off the ground water, causes a fall in the latter. On the sea-coast the ground, water oscillations probably correspond with the tides. The writer is not aware of any observations made to determine this point. In Munich, where the ground water flows toward the river Isar, which divides the city, it has been found that the annual range or oscillation (the difference between the highest and lowest level during the year) is ten feet, while the horizontal movement amounts to fifteen feet per day. In Buda-Pesth the annual range was found by Fodor to be less than three feet, while in some portions of India it amounts to more than forty feet. As it is from the ground water that the greater portion of the supply of drinking water in the country and in villages and small towns is drawn, it becomes at once manifest how important it is to prevent, as far as possible, pollution of this source. Cesspools and manure heaps and pits, of necessity, contaminate the soil, and also ground water, for a distance below and around them, and such water is clearly unfit for drinking and other domestic purposes. Hence, the reason why wells should not be placed too near privies and manure heaps or pits becomes apparent.

Between the level of the ground water, or that portion of the soil where its pores are entirely occupied by the water—where, in other words, the ground is *saturated*—and the surface is a stratum of earth more or less *moist;* that is to say, the interstices of the soil are partly filled with water and partly with air. It is in this stratum that the processes of organic decay or putrefaction are going on, in consequence of which the pollution of the ground air occurs. Recent observations seem to show that these processes of decomposition are initiated and kept up by minute organisms, termed *bacteria*, just as fermentation in liquids containing sugar can only take place in the presence of the yeast plant. It has been found that when non-putrefactive decomposition goes on, there are always present multitudes of one variety of these minute organisms; while if putrefactive decomposition is going on, a different variety of these organisms is present. Just as, when a fermenting liquid becomes putrid, the yeast plant disappears and its place is taken by the ordinary bacteria of putrefaction, so in the soil, if the access of oxygen which is necessary to the life of the bacteria of decay is prevented, these organisms die and are succeeded by the organisms of putrefaction. It has been found that in a soil saturated with water the bacteria of decay cannot live, while those of putrefaction may flourish, because these later organisms can sustain life in the absence of oxygen. Prof. Fodor's researches indicate that the organism of non-putrefactive decomposition or decay is that which is termed by Cohn *bacterium lineola;* and that the *bacterium termo* is the principal organism of putrefaction.

IV.—THE DISEASES SPREAD BY SOIL IMPURITIES.

Given now an area of soil, say the ground upon which a house or city is built, with a moist stratum in which the processes of decay are active, and imagine a rise in the ground water. The ground air, charged with carbonic acid and other products of decomposition, is forced out of the pores of the soil by the rising ground water, and escapes into the external air, or through cellars and basements into houses, and may there produce disease. But the saturation of the soil with water prevents the further development of the bacteria of decay, and putrefaction takes place. If, now, the ground water sinks to its former level or below, the processes of decay again become very active in the moist stratum, and large quantities of carbonic acid and other inorganic compounds are produced. If the germs of infectious or contagious diseases have been introduced into the soil, they also multiply, and may escape with the movements of the ground air into the external atmosphere, and there produce their infective action.

This, it is held by Pettenkofer and his followers, is what actually occurs in cholera and typhoid fever. Prof. De Chaumont has laid down the rule that a soil with a persistently low stage of ground water, say 15 feet below the surface of the ground, is healthy; a persistently high stage of ground water, less than 5 feet below the surface, is unhealthy, while a fluctuating level of the ground water, especially if the changes are sudden and violent, is very unhealthy. This would lead us to expect that places where this fluctuation is very great would show a large mortality from such diseases as are attributed to impurities in the soil. And this we find especially true in India. In certain localities in India, cholera, for example, is endemic—that is to say, the disease is never entirely absent in such localities. Calcutta is one of these places. The rainy season begins about the first of May and continues until the end of October. During the next six months there is very little rain. It is fair to assume that the ground water rises during the rainy season, and checks decay and the multiplication of the germs of the disease in the soil, and that these processes become more active as the dry season advances and the ground water level falls. If we note the death rate from cholera in Calcutta, it will be found that it bears a distinct relation to the movement of the ground water. The deaths from cholera begin to increase from October, and reach their height in April. Dr. Macpherson, who has written a very elaborate history of Asiatic cholera, shows this relation very clearly. For twenty-six years the average annual rainfall was 63 inches. From May to October 57 inches fell, while the remaining 6 inches fell from November to April. The average number of deaths from cholera annually was 4,013. Of these, 1,238 died in the rainy season, while 2,775—nearly three-fourths—died during the period of dry weather.

In the cholera epidemics of 1866 and 1873 in Buda-Pesth, the same relations existed between the ground water and the cholera. As the level of the ground water rose, the cholera diminished, while the disease increased upon the sinking of the ground water. Exactly the same behavior was exhibited by the disease in Munich in 1873.

There seems good reason to believe that typhoid fever is propagated in consequence of movements of the ground water, in the same way as above explained for cholera. This does not exclude the infection of drinking water by the disease germ, since much of the drinking water used, as before stated, is drawn from the ground water. Pettenkofer, Buhl, and Virchow have shown that the death rate from typhoid fever has a distinct and definite relation to the ground water oscillations. This has been incontestably proved for two cities, Munich and Berlin. When the level of the ground water is above the average, typhoid fever decreases; when it is below the average, the number of cases becomes greater.

Facts at present on record indicate that the stage of the ground water has an unquestionable relation to the sickness rate from intermittent fever. Malarial fevers are generally believed to be the invariable accompaniments of life in marshy regions, and so they usually are. But it is a noteworthy fact that malarial diseases are neither most frequent nor most virulent when the swamps are full. It is in the latter part of summer and early autumn, when the water is being gradually evaporated, and the swampy soil is drying out here and there—when the decomposition becomes active—that the fevers begin. In the winter and spring, when the ground becomes saturated to the surface from the abundant precipitation, and the processes of decomposition are checked, the fever disappears or, at all events, the cases decrease in number and severity.

About twenty years ago Dr. Henry I. Bowditch, of Boston, called attention to the frequent connection between cases of pulmonary consumption and dampness of the soil upon which the patients lived. After a very extended and laborious investigation, Dr. Bowditch formulated these two propositions:

"First—A residence in or near a damp soil, whether that dampness be inherent in the soil itself or caused by percolation from adjacent ponds, rivers, meadows, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly other portions of the globe.

"Second—Consumption can be checked in its career, and possibly—nay, probably—prevented in some instances by attention to this law."

Dr. Buchanan, of England, about the same time showed that the thorough drainage of certain English cities had markedly diminished the deaths from consumption in the drained cities. So far as the writer is aware, not a single fact has been established which militates against the law laid down by Dr. Bowditch and as strongly supported by the statistical researches of Dr. Buchanan, yet hardly any notice has been taken of these results by physicians. Few know anything of them, and still fewer seem to have made practical use of such knowledge in advising patients. As corroborative of the views of Dr. Bowditch, the rarity of consumption in high and dry mountainous districts or plateaus may be cited.

V.—DISEASES OF ANIMALS PROBABLY DUE TO SIMILAR CONDITIONS OF THE SOIL.

The modern study of the sanitary relations of the soil is still in its infancy. Whatever definite knowledge has been gained relates merely to physical or chemical conditions of the soil and its atmosphere and moisture, or possibly the relations of these to the spread of certain diseases in human beings. But there is, perhaps, a wider application that may be made of such knowledge than has been heretofore suggested. The domestic animals which form such a large proportion of the wealth of this country—horses, cattle, sheep, and hogs—are liable to infectious and contagious diseases as well as human beings, and many millions of dollars are lost annually by the ravages of such diseases. Now, from what is known of such diseases as *splenic fever* among cattle, and of the so-called *swine plague*, it does not appear improbable to the writer that the source of infection is a soil polluted by the poisonous germ of the diseases, just as it seems demonstrated that cholera and typhoid fever, and possibly malarial fevers, are so caused. The laborious investigations of M. Pasteur in France have shown that the cause of splenic fever when once introduced into a locality will remain active for months and even years, and it does not seem out of place to suggest to the readers of this report, most of whom are interested in the preservation of the health of the domestic animals, that a study of the soil in its relations to the diseases of these animals is a subject to which they may direct their attention with profit.

It is well known that milch cows frequently suffer from a disease identical in its nature with the consumption in human beings. It is believed by many that the milk of such animals is not only unfit for food by reason of its poor quality, but that it may convey the disease to human beings when used as food. The observations of Bowditch and Buchanan, quoted above, show that consumption in man may be, and doubtless is, frequently caused by soil wetness It seems probable that the same cause should produce similar effects in the lower animals, and it is the writer's firm conviction that an examination into the circumstances under which cows get consumption would prove this probability a fact.

VI.—THE PREVENTIVE REMEDY—DRAINAGE.

To secure a constant level of the ground water at a sufficient depth below the surface, drainage is necessary in many soils. Agriculturists know the value of proper and efficient drainage in improving the productive capacity of wet soils, but the men who build houses for human beings to live in, or stables to shelter animals, never give this matter much thought. Few of our architects have ever heard of the injunction of the ancient master of their craft, quoted in the beginning of this paper, to select a healthy soil upon which to build a dwelling, while a stable is frequently built partly underground, and in localities where all the conditions promoting disease are present. If farmers can once be made to understand that a wet stable, whether for horses, cows, sheep, or hogs, is an unhealthy stable, reform would soon be introduced. If they could be further convinced that a marshy or springy soil is not a healthy pasture ground, such places would soon be drained. If it were found, then, that by taking these precautions the health of animals was improved and their lives preserved, perhaps architects and builders in town and country would also learn that a dwelling cannot be healthy and comfortable unless built upon a clean, dry soil.

The Boston *Watchman* says that within the last nine years nearly eight hundred churches have been burned in America. A church that will not burn seems to be a much needed invention.

A SHOE THAT WILL NOT PINCH.—A SHORT STUDY IN THE HYGIENE OF THE FEET.

By BENJAMIN LEE, M.D.

COMPARATIVELY few Americans walk with their feet. I do not say *on*, but *with*. There is a vast difference. Most of us walk *on* a solidly compressed mass of flesh and bone, about as elastic and pliant as the last on which our shoes are made. A block of wood jointed on at the end of the leg would be exactly as useful; in fact more so, because it would be impossible, by any amount of squeezing, to give it corns. To walk *with* the foot is to allow all its joints free play, and to call into action all its muscles, to allow its skeleton to assume its natural position and relations in every stage of the step, and to avail ourselves of the entire spring given by its beautiful arch. But a small foot is the American's only

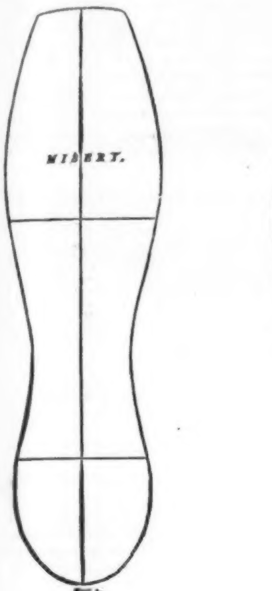


FIG. 1.

FIG. 2.

patent of nobility. It proves his extraction from a race of nobles and kings, which his democratic instincts teach him is a most desirable thing. Hence, he cultivates it as sedulously as a Chinese woman. The result is, a disinclination to walk, great fatigue in walking, a shuffling, inelegant, inelastic gait, and corns, bunions, and deformities. The first requisite for the adequate use of the feet, and hence for acquiring an easy, graceful, springy gait and noble carriage, is a properly constructed shoe. When I say that a properly constructed shoe is one which conforms to the natural shape of the human foot, or, in other words, one which is made in accordance with anatomical principles, I am uttering so simple a truism that it may provoke a smile; and yet I venture to assert that not one in ten of those who read this paragraph are thus shod in conformity with nature's demands. The principles which should determine the shape of the shoe were first distinctly enunciated by a distinguished German physician, Prof. Herman Meyer, of the University of Zurich, in a pithy little pamphlet entitled "Why the Shoe Pinches."

I suggest to the American Tract Society the expediency of giving this brochure a wide circulation as a tract, believing that it would do more to discourage the habit of profane swearing than all the essays on the third commandment

FIG. 5.

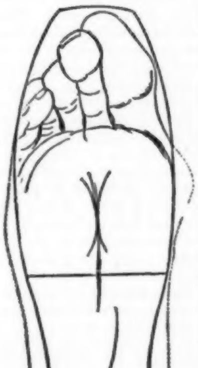


FIG. 6.

that have ever issued from its teeming press. Its essential ideas are that the axis of the sole of the foot is a curve, and not a straight line, and that the outline of the inner side of the foot and great toe is a straight line and not a curve, both propositions being directly the reverse of the dogmas of the disciples of St. Crispin and of the French boot-maker.

By the sole of the foot I understand that portion of the naked foot which comes in contact with the ground in walking, and for which it is necessary to provide protection from such contact in the shape of the sole of the shoe. By the axis of the sole I understand a line, starting at the middle of the posterior edge of the heel, or *os calcis*, and running forward in the median line of the sole until it terminates at the middle the toes, which point lies usually between the second and third toes. Now, this line will be found to be straight for little more than the length of the *os calcis*; it then begins to diverge toward the mesial line of the body or inner side of the foot. If continued as a straight line, instead of striking the middle of the foot anteriorly, it will, in the great majority of cases, strike the middle of the little toe. The two diagrams, one with a straight sole—the ideal of the shoe-maker, marked MISERY—and the other with a curved sole—the ideal of the anatomist, of the artist, and, I say it with all reverence, of the Creator, marked COMFORT—will serve to illustrate better than it is possible by words to convey a correct idea of the respective conditions.

The aim of the shoemaker has been to make each foot symmetrical in itself, while the foot, being a double organ, follows the law of all double organs, and is symmetrical only

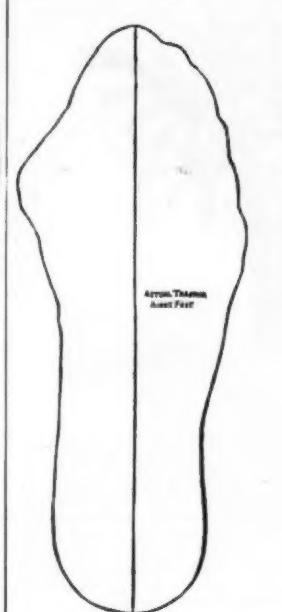


FIG. 3.

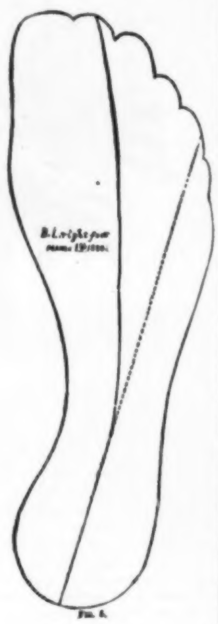


FIG. 4.

with its fellow. In carrying out this aim he has made the shoe not simply what it should be, a covering for and protection to the foot, but an *orthopædic instrument*, the object of which is to straighten out its natural curve.

A glance at the third diagram will show at what points the pressure is applied in order to produce this result. They are observed to be the inner side of the heel, the outer side of the middle of the foot, and the inner side of the great toe. It will also be noticed that, at the same time that strong pressure is brought to bear upon the first or metatarsal joint of the great toe, its distal extremity is forced toward the middle line of the foot; the result of this necessarily is to convert the inner surface of the articular portion of the metatarsal bone into a fulcrum, against which the first phalanx is forced outward. The articular surface of the phalanx is thus uncovered, and instead of remaining in contact with the opposite articulating surface of the metatarsal bone, it is in contact with the shoe, protected only by integument. A provisional bursa is sometimes established, itself often the seat of inflammation; but this does not prevent the sensitive joint surface and the synovial membrane from ultimately receiving injurious pressure, which results in the hideous and painful deformity known as a *bunion*. At the

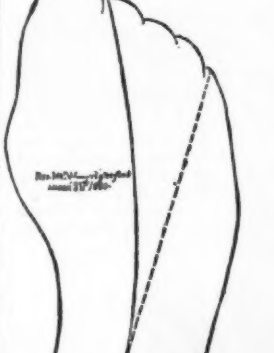


FIG. 7.

FIG. 8.

other end of the toe the continued pressure against the matrix of the nail induces a suppurative inflammation of low grade, with fungous granulations, to which the name of *in-growing toe-nail* is given; while the other toes, crowded together and overlapping, are not long in becoming knobbed with corns and callosities. By dint of beginning in early infancy or childhood, as Chinese mothers do, the shoemakers sometimes completely succeeds in his object of straightening out the curve of the foot. The next diagram shows the tracing of an actual foot. Its axis is a straight line from the middle of the heel to the middle of the toes; but at what a fearful cost of years of suffering, as witnessed by this enormous bunion, has the result been obtained. It may well be doubted whether, to use the expressive French phrase, the "game has been worth the candle."

The process of deforming the foot of an American child is usually about as follows: As soon as the victim is able to walk, a pair of straight-soled shoes, rather narrower than the feet, is provided for it. In the course of a few weeks the shoes, being worn the one habitually on the right and the other on the left foot, begin to take the shape of the respective feet. This is no sooner observed by the careful mother than she exclaims: "Why, Johnny! you're wearing your new shoes all out of shape; you must change, and wear them on the other feet." And if Johnny forgets, finding the change by no means conducive to comfort, he is whipped, to aid his memory. It will readily be understood how well adapted these shoes, now conformed to the natural curves of the feet, are to straighten out the curves of the opposite feet. By this simple means, repeated as often as the feet begin to assert their independence, and persistently carried out, it often happens that by the time a child is six years old its great toe will be seriously deflected from the rectilinear position, which it ought to occupy, and the curve of the sole partially straightened. Fortunately, both lasts and ready-made shoes can now be obtained which approximate quite closely to the natural shape of the foot; and not only can the foot of the child be preserved perfect as it grows up by using such lasts and shoes, but a foot which is already somewhat distorted may even be coaxed back more or less nearly to its original shape. The annexed diagram shows the outline of a foot which, once distorted, has thus been afforded an opportunity of regaining its pristine form.

The diagram of the following cut shows the tracing of a tolerably natural foot which I happened to obtain in the following way:

A patient observed the tracing of my own foot lying on my desk. Picking it up, he regarded it mournfully for a moment, heaved a deep sigh, and said: "Ah! doctor, that is just the deformity of my little boy's foot. I must bring him to see you." While expressing my sympathy with his little son's misfortune, I assured him he was in error in supposing that the drawing represented a deformed foot, as it was that of my own, which was tolerably natural.

Finding it was impossible to overcome his credulity on this point, I glanced down at his own feet, and noticed that he wore a good, generous, broad-soled shoe, which could not have produced much distortion, and said confidently: "I venture to say that your own foot is nearly as crooked as mine." He at once took off his shoe and stocking in order to disprove the truth of my assertion, and this diagram was the result.

The ready-made shoe to which I have referred as conforming to the principle I have announced is known as the "Waukenphast," first introduced under that name in England, but now manufactured quite extensively in New England.—*Sanitarian*.

[From THE SCIENTIFIC AMERICAN of May 13, 1871.]

GALVANIZED IRON PIPES. THEIR DANGER WHEN USED FOR CONVEYING DRINKING WATER.

PIPES FOR DOMESTIC WATER SERVICE.

THERE is nothing about which we receive more numerous inquiries than water pipes. Most people are getting suspicious of lead for this purpose, it having been shown that this metal often contaminates the potable waters conveyed through pipes made of it. For a time quite a popular impression prevailed that in zincked, or, as commonly called, galvanized, iron pipes the cheap and safe water conduit for domestic purposes had been found. This is still maintained by some, and it is with a view to throw additional light upon the subject that the present article is written.

There is no doubt, as we have shown in previous articles, that iron pipes thoroughly coated with zinc, and conveying perfectly pure water, will not contaminate the water to any appreciable or hurtful degree. Waters containing acids or free alkalies will, however, speedily become charged with the oxides or salts of zinc, to a greater or less extent depending upon the character of the water. In some cases, where there does not appear to be a notable amount of alkalies, acids, or salts, the solutions of which dissolve or combine with zinc oxide, there is still rapid attack upon the metal.

We have a specimen of such a pipe that is nearly filled with a deposit of metallic origin, resembling mixed metallic zinc and red oxide of iron. An analysis of this deposit would be interesting.

Pure water acts more powerfully upon lead than upon zinc. While the oxide of lead is readily soluble in water free from carbonic acid, it is converted into a comparatively insoluble or difficultly soluble carbonate whenever it is exposed to water containing carbonic acid.

In experiments made by the government commissions appointed to examine into the chemical quality of the water supply of London, the extraordinary effect produced by a small quantity of carbonic acid in the way described was most particularly noted. Pure distilled water placed in contact with lead became highly poisonous, while that containing three per cent. of its volume of carbonic acid remained safe; they decided that sufficient carbonic acid is usually found in well, river, and spring waters to render lead pipes a safe means for conducting them.

Notwithstanding this, they admit that, from causes little understood, water will at times act with unusual energy upon lead; and we have no doubt that imperfectly understood conditions will often render it powerfully energetic in its action upon zinc-coated iron pipes. The specimen of this kind of pipes, above referred to, which has almost become stopped by its deposit of mixed oxide, metallic granules, and salts, would seem to indicate this, as the water which flowed through it has always been regarded as being of ordinary purity for drinking and culinary purposes.

A prominent leader in the Shaker family at New Lebanon, N. Y., assures us that they have not succeeded in the use of zinc-coated pipes, and regarding lead with disfavor, they are meditating a return to the old pump-log service, once so much used in this country.

We are cognizant of another example, in a town near Boston, Mass., where a new house was piped with galvanized iron pipes. Sickness soon overtook the family, one of its young members died, and a post mortem examination revealed the presence of salts of zinc in the stomach and other organs. Death was directly attributed to the use of these pipes.

Mr. Robert Rawlinson testified before the commission referred to, that galvanizing iron pipes is a delusion. He said:

"If the pipes are laid in subsoils which will act upon iron, the galvanizing affords no protection against that action, and there are soils which will rapidly eat away either iron or lead.

"If you examine a galvanized iron pipe under a micro-

scope, you will find that it is not an even coating; it is freckled, and there are interstices, oxidation sets up, and then the galvanizing is blistered off, it does not improve, and even so far as does cover it, I doubt very much whether it preserves it; it is not stronger in its texture, and it certainly does not last longer; that is my experience."

Mr. Thomas Duncan, engineer of the Liverpool water works, stated that the effect of soft water upon iron pipes was to produce an infinite number of small tubercles, those who have grown up, and they project in many instances for about three-quarters of an inch, reducing the diameter of the pipe between point and point 1½ inches, thereby increasing the friction. They form an infinite number of little eddies, and it is not only the space they occupy in the pipe, but from my observation I believe the effects extend much further into the interior of the pipe, and disturb the current.

A method has been recently patented for coating pipes internally by silver electro-plating therein. Water containing sulphur would, of course, in time convert such a coating into the sulphide of silver; but this, being insoluble in water, would protect the pipes as well as the metallic silver. Should the water contain any alkaline hyposulphites and also free chloride, the silver may be gradually converted into a chloride, which being dissolved by ammonia would after a time result in the denudation of the lead. Of course the time required for this action, if it should take place, can only be determined by experiment; but in such waters as contain traces of the substance named, such action would seem likely to result ultimately. It is known that silver exposed to an atmosphere containing chlorine will gradually blacken from the formation of chloride, and it is probable that this would occur to some extent in water pipes coated with silver.

The cost of the metal will stand in the way of using a very thick coating, and therefore any chemical action will be more apt to interfere with the economical application of silver to this purpose.

In Boston the lined copper pipes are coming into vogue, and are pronounced perfectly safe in all respects. The copper is tinned before being made into tubes, and the interior of the pipe is again tinned when made up. The expense of these pipes is about the same as lead pipes of equal strength.

ON ANALGESIA

DR. BROWN-SÉQUARD has written the following very interesting letter to the *Lancet:* "Sir—My pupils, not I, have proposed to employ on our species the method I have discovered of producing analgesia in monkeys, dogs, and other animals. I am not prepared to make such a proposal; not that there is any danger in the method, nor that the degree of analgesia is insufficient, but because I have not yet succeeded in devising for clinical use an easy means of applying carbonic acid or chloroform vapor to the mucous membrane of the larynx, without allowing these substances to go into the lungs. This last point is of absolute necessity, as when these substances enter the blood they can no longer produce, by irritation of the mucous lining of the larynx, their wonderful effects. My experiments, some already published, others quite new, show that an irritation of the laryngeal mucous membrane (and also, but in a much slighter degree, of the lining of the upper part of the trachea) can, though the superior laryngeal nerves, or even through one of them only (but then the analgesic effect is chiefly unilateral), act on the nervous centers in such a way as to produce a more or less complete inhibition of either the power of perceiving impressions able to give rise to pain, or of the power of transmitting those impressions. Every kind of irritation (mechanical, thermic, chemical, or galvanic) of the terminal ramifications of the superior laryngeal nerves can produce that effect; but none in the same degree and with so great a persistence (in monkeys sometimes the analgesia lasts more than twenty-four hours) as the excitation due to carbonic acid or chloroform vapor, the first especially. The power of the parts I have named in producing an inhibition of the kind of sensibility relating to pain, without disturbing any other power or function of the nervous centers, is so great that sometimes a partial section of the larynx or trachea produces a temporary and almost universal, but incomplete analgesia."

DISCOLORATION OF THE HAIR.

By GEORGE THOMAS JACKSON, M.D., Attending Physician Demilt Dispensary, Department of the Skin, etc.

UNDER varying conditions of health and disease, the hair has been noted to undergo discoloration other than that of turning gray. Some of these changes are due to external agencies acting after the manner of dyes, and some to internal agencies.

Blue hair has been observed frequently among workers in cobalt mines and in indigo works. *Green hair* occurs in workers in copper, the tone becoming darker from year to year till the hair becomes decidedly green. In both these cases the color is due to a deposition of the particles of the mineral or vegetable floating in the atmosphere upon the cuticle of the hair. The color can be entirely washed out, and the microscope shows that it is from without and not from within the hair.

Prentiss* reports a case of change of color of the hair from light blond to nearly jet black in a patient suffering from pyelonephritis with anuria, for the relief of which muriate of pilocarpine was used hypodermically. The use of the drug was begun December 16, 1880, and the hair began to change in twelve days. The drug was not administered after February 22, 1881, but the color continued growing darker, so that by May 1, 1881, the hair which originally was light blond with a yellow tinge had become nearly jet black. The change in the color was noted both on the head and in the axillæ, and simultaneously with it the hair became coarser and more vigorous. The color of the eye changed from light blue to dark blue. These changes were due to increase of normal pigment.

That the color of the hair may change after death is shown by a case reported by Hauptmann,† in which, on exhuming a body that had been buried twenty years, the hair was found to have changed from a dark brown to a red color.

Leonard‡ cites a case in which after death a head of red hair changed, within thirty hours, to a gray color. Other cases have been reported in which, after illness, the hair has altered its color, gradually to regain its normal hue when recovery has taken place. Smyly§ has recently reported a case of suppurative disease of the left temporal bone, in which the color of the hair changed from a mouse color to a reddish yellow. Squire* reports a piebald condition of the hair of the head, occurring in a deaf and dumb boy of sixteen years of age. In this case the left side of the head hair looked like the fur of a tortoise shell cat, with light patches of true auburn tint and dark patches of dark brown color, the patches being sharply limited. This condition had existed from birth. The other side of the head was covered with dark brown hair. Exposure of the hair to the fumes of chlorine gas will bleach it.—*Journal of Cutaneous Diseases.*

* Phila. Med. Times, 1881, xi., 609.

† Virchow's Archiv, 1859, xlvi., 502.

‡ The Hair, etc. Detroit, 1881.

§ Med. Press and Circ., 1883, xxxv., 184.

* Lancet, 1881, ii., 74.

DECORATIVE PALMS.

To cultivators whose knowledge of palms is limited to an experience with them when small and serviceable for pot work, it may be interesting to learn that almost the whole of

LIVISTONA HOOGENDORPI.

the plants which belong to the great palm order are, when fully developed, quite tree-like in their proportions, and not a few of them are even worthy of comparison with the mammoth pines of the forests of North America. It is the assumption of a graceful ornamental habit almost as soon as they are developed from the seed, and their continuance in such habit until they are of mature growth, that has led to the popularity of a large number of palms in all the work appertaining to the decorator and the plantsman's art. Palms, either fan-leaved, or plumose, or feather-like, always occupy one of the principal positions in the decoration of rooms, dinner tables, balls, and at all festivities, and among the mixed collections of stove and greenhouse plants they figure largely

CALAMUS LINDENI.

and always with striking effect. Recently even the theaters have begun to add to their attractions a selection of graceful palms, which, placed about the auditorium, or upon the stage itself, lend an air of grace and refinement to the surroundings. We are as yet only in the beginning of art of this kind. In Continental towns it is rarely indeed that one enters a place of public entertainment, a cafe, or a restaurant, and fails to find a free sprinkling of graceful foliage and flowering plants, adding light and beauty such as plants only do add to such places. Palms, of course, figure prominently in all work of this kind, a fact which to a large extent accounts for the great popularity of the palm order with our own Continental brethren and the enormous numbers of

WASHINGTONIA FILIFERA.

them grown for purposes of decoration. It is surprising to an English gardener to note the numberless kinds that are employed in France, Belgium, and Germany for the embellishment of balls, etc., many of them, too, such as he has been carefully coddling, from the impression that they were delicate and incapable of standing anything but good treatment. By a system of gradual hardening off, so as to inure the plants to the rough life they are destined for, a large number of palms are made serviceable for the decorator's use in foreign towns, and it appears to us that a great deal more might be done by cultivators here in providing more variety of foliage for uses of a similar kind. Palms, from their robust, bony nature, are especially adapted for this kind of work. The three species represented by the accompanying woodcuts may be instanced as possessing both in appearance and sturdiness of constitution the requirements essential in a useful furnishing plant. Of the first, Livistona Hoogendorpi, it may be said that, like its relations, L. chinensis (Latania borbonica) and L. rotundifolia, it may be used with impunity for furnishing of all kinds. Dwarfer in stature, with leaf stalks covered with stout brown spines, and the leaf blade divided almost from its base into a number of arching segments, it is quite distinct from the two other species here mentioned. Washingtonia filifera (Pritchardia filamentosa) might be called the weeping willow palm, the long, silky filaments that hang in such profusion from its graceful fan leaves giving it an appearance not unlike that tree. It is almost hardy, being a native of the Southern States of North America, but happiest when grown in a warm greenhouse, and if a large specimen is desired, when planted in a border. Being a quick grower, it soon develops into a useful size. The third plant is Calamus Lindeni of gardens, though whether a Calamus or an Oncosperma it is not yet possible to say. M. Linden introduced it from the East Indies a year or two ago. The leaves are bright green above and silvery on the under side.

There is a host of Calami of habit similar to this, and although they are all natives of tropical regions, they may be so managed in this country as to prove available for decorative work. The Kentias, Seaforthias, Chamærops, Phœnixes, Hyophorbes, and many other genera comprise plants that prove of great value for a similar purpose.—*B., The Garden.*

[NATURE.]

FAIRY RINGS.

THE dark green circles of grass known as "fairy rings" formed the subject of a paper in the *Philosophical Transactions* of the new-born Royal Society in 1675; but it was only last year that the Rothamsted chemists, Messrs. Lawes, Gilbert, and Warrington, announced what is no doubt a correct explanation of these phenomena.

The original theory of the electrical origin of the rings was succeeded by that of "chemical causes," propounded by Dr. Wollaston at a meeting of the Royal Society in 1807, and by Prof. Way in a paper read to the British Association in 1846. Besides the "mineral theory," which was here pressed into the service of a discussion that commenced, as already stated, more than two hundred years ago, De Candolle applied his famous "excretory theory" to its elucidation. At Rothamsted, however, the causes of fairy rings were still regarded as having been unsatisfactorily explained.

Sir John B. Lawes and his colleague Dr. Gilbert commenced their inquries on this subject many years ago. Almost from the commencement of their experiments at Rothamsted they had regarded the alternate growth of fungi and grass as a striking example of what may be called the "natural rotation" of crops. As long ago as 1851 they described fairy rings in the *Journal of the Royal Agricultural Society* as "a beautiful illustration of the dependence for luxuriant growth of one plant upon another of different habits. It will be remembered that the experiments at Rothamsted led to the substitution of what is called the "nitrogen theory" for the "mineral theory" of former days, and practical agriculturists who know the value and the cost of nitrogen as an all-important agent of fertility will learn, perhaps without surprise, that the rich verdure of a fairy ring is due to the effect of nitrogen. Nitrogen is the *sine qua non* of plant growth, and fungi require a large amount of it. From what source do they obtain it? At the present time few, if any, chemists would maintain that they obtained it by the absorption of free nitrogen from the atmosphere, but in 1851 the eminent investigators at Rothamsted attributed the nitrogen of the fungi to their extraordinary power of accumulating that substance from the atmosphere; and this they thought enabled them to take up the minerals which the grasses, owing to their more limited power of obtaining nitrogen, could not appropriate from the soil. They assumed that it was the nitrogen rather than the mineral constituents of the fungi to which the manuring action was mainly to be attributed, and in this they were right; but the theory has required some correction nevertheless, inasmuch as they have since proved the source of nitrogen in the fungi to be the soil, not the atmosphere.

As doubts were entertained at first on this point, direct experiments were tried at Rothamsted, and in 1874 samples of soil were taken within a fairy ring, immediately upon it, and outside, and these yielded on analysis the lowest percentage of nitrogen in the soil within the ring, a higher percentage under the ring, and a higher still outside. The soil therefore had lost nitrogen by the growth of the fungi, and the obvious conclusion was that the fungi possesses a greater power than the grasses of abstracting nitrogen from the soil.

The analyses of the various species of fairy ring fungi do not greatly differ. Two species occurring at Rothamsted—*Agaricus prunulus* and *Marasmius orcadum*—contain nitrogenous compounds to the amount of one-third of their dry substance, the ash being rich in potash and phosphoric acid. Their occurrence on pastures, like that of the common mushroom, is probably due to the manuring of the ground by animals, and their continuance and growth depend on certain conditions of soil and season. They are rarely developed on rich soils, or on those which are highly manured, or in seasons favorable to the general herbage of the turf; and when they do appear under these conditions they will probably not be reproduced, or only in patches. The recent wet seasons have dispersed fairy rings in situations where they have usually proved persistent. They prevail wherever the growth of the grasses is inferior, especially on the poor downs of the chalk districts, and on poor, sandy soils where the natural herbage is wanting in vigor.

The history of fairy rings, as it has now been written at Rothamsted, will attract close attention from all who are interested in the nutrition of plants, including the student of agriculture, and all, in fact, who are specially concerned in the question of the food supply. It was not previously known that any kind of plant could feed directly on the organic nitrogen of the soil itself. It was recognized that the root-development of plants differed, and that the greater extension of their roots enabled some plants to secure a larger proportion of the constituents of the soil than others. But here is a race of plants possessing quite unsuspected powers of assimilation! Instead of rising from the ashes of the phœnix they fed upon its undecayed body, that is, upon the organic nitrogen of the soil. The Leguminosæ, for example, such as beans and clover, are known to assimilate more nitrogen

from a given soil than the Gramineæ, such as wheat and barley, and this has been attributed to absorption by their leaves or to the superior development of their roots. Another alternative is now suggested, and possibly a new departure may be taken in the science of agriculture, as the result of the recent discoveries in connection with the fairy rings.

HENRY EVERSHED.

SUPERPHOSPHATES FROM BEAUFORT RIVER PHOSPHATE ROCK.

To the Editor of the Scientific American:

The following facts may be of some interest to manufacturers of fertilizers, especially those who contemplate using phosphate rock from Beaufort River, S. C. This rock contains very small quantities of iron and alumina, varying from 1 to 2 per cent. In bone phosphate of lime it varies from 52 to 56 per cent., but it is quite uniform as compared with some other phosphate rock now in use.

A fact connected with the manufacture of superphosphate of lime from this rock is that it yields results in available phosphoric acid equal to such rock as Coosaw, which analyzes from 58 per cent. to 60 per cent bone phosphate. The Beaufort rock contains a much larger percentage of calcium fluoride, which when mixed with sulphuric acid is decomposed, and fluorine combines with silica present and forms silicon tetrafluoride, which volatilizes as a gas.

The average composition of Beaufort rock is:

Bone phos. of lime	54	to 56 per cent.
Carbonate " "	12	" 13 " "
Sand	19	" 20 " "
Ferric oxide and alumina	1	" 2 " "
Calcium fluoride	2	" 4 " "
Organic matter and water of comp.	2	" 3 " "
Soda and magnesia	1	" 2 " "
Moisture	0·5	" 1 " "

Using the following formula:

Rock	1,100 lb.
Chamber acid (50° B.)	900 "
	2,000 "
Less 10 per cent. loss	200 "
Net product	1,800 "

This will give a superphosphate analyzing 14 to 15 per cent. available phos. acid.

J. H. PRATT.

Beaufort, S. C., May 25, 1884.

THE MOVING SANDS AND BRECCIA PILLARS OF TURKESTAN.

TURKESTAN presents a large number of interesting geological phenomena, such as burning mountains, moving sands, and pillars of breccia, which we had occasion to study at the time of our last exploring tour across Central Asia, and which we shall now describe to our readers. The first of these, which probably gave rise to the belief that active volcanoes exist in Thianschan, are merely extensive strata of charcoal that have been burning underground for a long time. The moving sands are one of the plagues of Ferghanah (Fig. 1) and of certain parts of Bokhara. They are similar in their effects to the formerly so dreaded sands of Gascony, and they move forward over the land with a disheartening certainty, burying roads, fields, and houses. The village of Anderchan was compelled to fly before these sands, and was transported two kilometers further along. The old spot at present offers nothing but ruins covered with sand, through which project the apices of nine willows. Out of 34 hectares of cultivated land at Patar, 13 have been buried. The progressive movement of the dunes may be estimated at 14·2 meters per annum. The sand is extremely fine, and flows like oil. A horse will become buried in it knee-deep. It contains 70 per cent of quartz. Sometimes, when the wind blows violently, it carries along in its track innumerable grains of sand that obscure the light of day and give the atmosphere and landscape that wan, leaden-gray tint that foretells some catastrophe. These atmospheric storms are known by the name of *garmsal* in summer and *bourrane* in winter.

The bourranes of the steppes have more than once proved fatal to caravans by burying them in a winding-sheet of sand. The indigenes, seeing their lands encroached upon by dunes, consider the moving sands and locusts that at times desolate their country as a punishment inflicted by an angered divinity.

Under the unilateral action of the wind the mounds of sand assume a peculiar horse-shoe form. The crescents thus formed are styled *barkhanes*. The sands are derived from the deposits made by mountain torrents, from brooks that carry along pebbles, from the erosion of jurassic and cretaceous rocks, from sandstones of the lower tertiary, from the disintegration of the upper tertiary formation, and, finally, from deposits of sand formed by the Syr or Amon Darja. Small pools of water that are scattered here and there in the steppes stop the sands and form the nuclei of future barkhanes. Wherever these latter exist we are almost always sure of finding water. There is nothing but vegetation that can surely stop these sands, and the natives have more than once learned this to their cost. In the time of Choudaiar, Khan of Khokand, the vegetation of the dunes was allowed to remain, and the sands were arrested. Shortly afterward the natives pulled up the plants in order to utilize them as fuel, and the sands then began their forward motion and buried the cultivated fields. In the village of Kalamouch the inhabitants sacrificed a portion of their gardens in order to plant trees therein, when the barkhanes advanced to the middle of these plantations and then stopped. Among the most efficient plants for fixing these sands may be cited *Arundo arenaria, Alhagi camelorum, Halimodendron argenteum*, artemisias, poplars, etc. The natives now know that it is to their interest to preserve the vegetation, and are all disposed to accept the rules proposed by the Russian Commission for the fixation of the dunes. This Commission is guided by the splendid results obtained in Gascony, but it were to be desired, in the interest of the country, that its labors were a little less theoretical, in view of the imminence of the danger.

The quaternary deposits attain a remarkable development in the valleys of Thianschan. Large deposits of conglomerate, breccia, alluvion, etc., fill the bottom of the long terminal valleys up to a height of 100 meters or more, and to altitudes of from 7,000 to 8,000 feet. These deposits are usually channeled to great depths by swift rivers, such as the Zerofchane, Jaguaon, Iskander, Tchotkal, etc. These ravines generally run in the direction of the greatest superficial slope. These subterranean channels are readily formed in the loess, and it is to just such phenomena as these that are attributed those earthquakes that slightly shake the soil of Turkestan.

One of the most curious phenomena connected with erosion may be observed near Anzob in the valley of the Jagnaous (Kohistan). There, as in two-thirds of the valley, great strata of breccia line the sides of the valley up to a considerable height. Upon a slope that has an incline of 30 or 40 degrees may be seen standing tall, slender columns of breccia each crowned with a large stone like a capital. From a distance this curious architecture looks like a collection of gigantic toadstools (Fig. 2). These columns in some cases reach a height of 10 meters. They are variously spaced and are of different heights and diameters, and this further adds to the strangeness of the landscape. The capstones are of irregular shapes, and their center of gravity is perceptibly in the axis of the columns, so that the block sometimes hangs over considerably on its wider and thin side, while it scarcely projects on the opposite. The formation of these columns is easily explained. At a time when the continual erosion due to atmospheric agents had not as yet given the valley its present depth by excavating and carrying off the earth, the layers of breccia formed a sort of plateau slightly inclined toward the median line. Then, as now, immense blocks occasionally detached themselves from the side banks and rolled over the incline without, however, reaching the center of the valley. Slow erosions, made by streams and torrents, afterward carved out the rocks to a great depth, and gave the valley its present form. The vertical sections of breccia underlying the blocks, being more coherent and solid as a consequence of the pressure exerted by the latter, resisted the erosive action of the water for a greater length of time, and were thus spared. The simple trenches that began at first to form between two of the blocks finally extended, and isolated angular columns. Then the angles began to slowly wear away, and the shafts finally became round.

These geological formations, whose importance, as regards our understanding subsequent geological phenomena, is greater than might at first sight be thought, prove that the waters quickly retired and left to violent torrents, descending from great heights, the work of deeply channeling the mass of breccia and conglomerate that filled the valleys.—*G. Capus, in La Nature.*

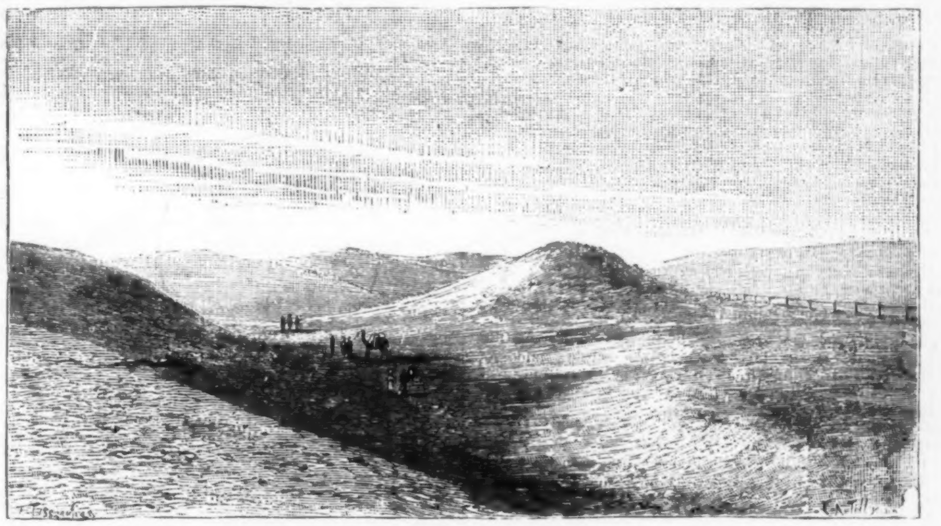


FIG. 1.—HILLS OF MOVING SAND IN FERGHANAH, CENTRAL ASIA.

MATTER AND GRAVITY.

ALL material bodies, if considered as centers of lines of tension or pressure which traverse the spaces between them, will manifest a tendency to mutual approach. If then we suppose a perfectly elastic ether to exist, and all bodies to be condensed ether originally produced by a compressive force which still continues and maintains the primal concentric strains which produce them, would not gravitative action with them necessarily follow? For every material particle would be the center of an ethereal stress, the force of which would be in proportion to its mass, and as sensible matter is immeasurably small in amount as compared with the pure ether the stresses centering in every body, although universal in extent, would be proportionally weak, and consequently such would be the manifested tractive force. The tendency of bodies to come together would thus really be the tendency to equilibration of the ethereal strains, and which could only be reached by all dense matter coming together and forming one center of a universal sphere of stress; the only mode of

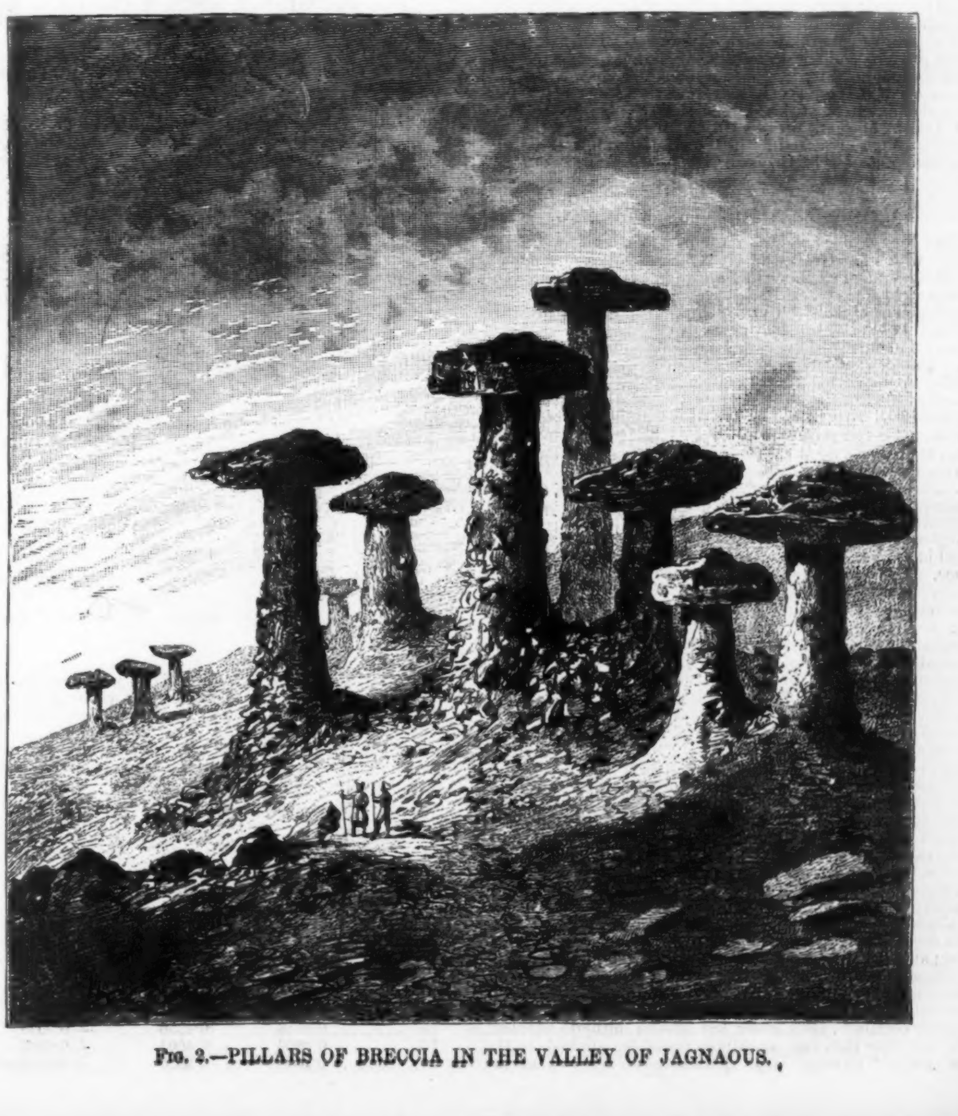


FIG. 2.—PILLARS OF BRECCIA IN THE VALLEY OF JAGNAOUS.

counterbalancing this tendency being the force of tangential motion, such as we see in all cosmic systems. The apparently greater density of the ether within and around dense matter, as deduced from the phenomena of refraction, also favors this view.

Of course this principle of the conservation of matter lies outside the range of physical science, and requires the constant operation of a power above nature; but there is nothing miraculous about it, in the sense of deviation from natural experience. It is intelligible, and offers hinderance to no mode of investigation; and as some philosophers have held that the conservation of energy is simply the maintenance of the primeval creative force, and that the universe would no longer exist were that force withdrawn, I consider the postulate allowable. Besides, I am not aware that the mechanical conception of matter as *necessitating gravitative action* has ever before been put forth, even as being maintained by a power above nature.

W. D.

THE MANUFACTURE OF VIOLINS IN GERMANY.

IN the No. 3 Museum at Kew a very interesting series is exhibited illustrating the manufacture of violins in Germany. It seems from the descriptive label which accompanies them that the woods used in this manufacture are the following: Norway Spruce (Picea [Abies] excelsa) for the resounding cover, technically called the belly, the vertical fastening of the body, and the sound-post; Maple (Acer Pseudo-Platanus) for the back, the corners, and the neck; Lime (Tilia europæa) for the horizontal fastening of the body; Beech (Fagus sylvatica) for the bridge; White Beam tree (Pyrus Aria), dyed black, for the body of the finger-board; and Ebony (Diospyros Ebenum) for the tailpiece, or string-holder, the surface of the finger-board, and the pegs. The following interesting description accompanies this series:

On the road from Munich to Innsbruck, the last Bavarian population is the small townlet of Mittenwald on the Isar. Situated at a high elevation at the entrance of the Alps, its agriculture is poor, and the inhabitants derive their livelihood principally from the forests were the Spruce Fir and and the Beech predominate. The former yields in its wood the principal (resounding) material for musical instruments, and the whole of the male population of Mittenwald is occupied in this manufacture—the younger and infirm people through the whole year, the abled bodied at all times when they are prevented from working in the mountains. Every stranger passing this spot will be struck by the sight of hundreds of violins—tenors, violoncellos, double basses, guitars, and zithers—hanging about the doors, in sunshine and wind, in order to dry the varnish.

This branch of manufacture is some centuries old, dating from the time when the famous fiddle maker Jacobus Stainer brought the art from Italy and established himself at Absam, near Innsbruck. His pupil Klotz, and his sons after him, were the first who carried on the manufacture of these instruments in Mittenwald, and it has gradually increased so much that at the present time an astonishing number of such instruments are sent out from this locality to the whole world, viz., 15,000 violins, 400 violoncellos and tenors, 80 double basses, etc., annually. The manufacture of the single parts, their composition for an entire instrument, its adjustment and regulation, are taught in a practical school established in the reign of King Maximilian II., and skillful and experienced men are occupied in going from house to house to overlook the work, and help by their advice. Several tradesmen who carry on the sale of the instruments furnish the workmen with the wood, which must be carefully selected, dried for many years, prepared and cut with particular tools; the other materials are also supplied by them.

The genuine pattern of the most renowned Italian masters being procured, and every traditional particularity followed with scrupulous care, it is not rare to see produced here instruments of first quality, and manufactured with particular care, claiming to be of the highest merit, and equal to the old Amati, Guarneri, Stradivari, and Maggini. But the inferior qualities are asked for in the greatest number, and are supplied at astonishingly cheap prices.—*Gardeners' Chronicle.*

SALMON EGGS FOR NEW ZEALAND.

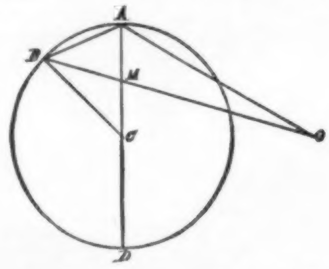
THE New Zealand Shipping Company's chartered steamer Ionic, which left Gravesend lately, takes out a consignment of 60,000 salmon eggs, packed on an entirely new principle in order to keep down the temperature and retard the development of the germ in the eggs. The method hitherto adopted in sending out consignments of ova to the colonies has been to surround the cases in which the eggs are deposited with blocks of ice, which it was too often found, besides taking up a large space and adding much to the cost, melted *en route*, causing the destruction of the eggs it was intended to preserve. Even if the supply of ice did not become exhausted, the excessive saturation of the moss in which the eggs are packed, by the percolation of the ice water, and the impossibility of effecting a change of the atmosphere in the packages, led to chemical action, or to the development of fungoid growths, which equally often proved fatal to a large proportion, if not the whole, of the eggs. The new system adopted is a modification of Haslam's refrigerating machinery used in the preservation of meats and other perishable produce. The Ionic, like the other vessels of the New Zealand Shipping Company, has been fitted with this apparatus by the Haslam Foundry and Engineering Company, of Derby, for the importation of "frozen" mutton and other New Zealand produce; but the total absence of moisture from the chilled air produced by the action of their machines, while absolutely necessary for the preservation of meat, would be fatal to salmon eggs. By an ingenious contrivance invented by Mr. Haslam, the air, though kept at a steady temperature of from 30 to 34 degrees—low enough to retard the development of the eggs without actually freezing them—is also so thoroughly saturated with moisture that a piece of dry flannel being hung up in the chamber in which the eggs are deposited becomes quite damp in the course of few hours. The air, reduced to this condition, is driven into the chamber and expelled again on the other side, at regular stated short intervals of time, so that all possibility of "mouldiness" and of too great saturation is prevented on the one hand, and of too dry cold or too great heat on the other. The machinery has been warmly approved of by Sir James Gibson Maitland, whose first hatchery at Howietown, near Stirling, has been so successful, and who collected the eggs in question; and there is every prospect that the shipment will be a complete success. If so, it will be possible to send out many millions of eggs at a time to any part of the world, not only in far less space and at less cost, but with much greater certainty, than under the system hitherto adopted. Further than this, the machinery could be applied to the purpose of "storing" large quantities of fish ova in the "hatcheries," and of retarding their development until such time as they could be conveniently hatched out. By this means large quantities of eggs collected at a time, in excess of the capacity of the "hatching troughs," could be kept in reserve and hatched out in batches, until room was made for them by the removal of their predecessors.

TO INSCRIBE A POLYGON WITHIN A CIRCLE.

To the Editor of the Scientific American:

In your SUPPLEMENT for May 17, I observe a communication from Capt. R. Kelso Carter, in which he gives a solution (as he claims) of the general problem in plane geometry, To inscribe a regular polygon of any number of sides in any circle. The construction given is not a genuine solution of the problem proposed, as the polygons obtained are not really regular, their sides, and generally their angles, differing by small amounts. Theoretically, therefore, the construction is no true solution. For practical drawing purposes, I think stepping dividers applied repeatedly to the circumference would be quicker and more satisfactory.

It is easy for any person who knows how to solve a plane triangle to show that the construction is not accurate. Take for example the figure on this page, and suppose the radius AC = 1, and that AM is one fourth of the diameter,



so that we are to inscribe a square in the circle. Then if O be the vertex of an equilateral triangle described on AD as a base, AB should be, if the construction were correct, the side of a regular inscribed octagon, and the angle BCA would be 45°. In order that this may be true, AB must be equal to twice the sine of $22\frac{1}{2}°$, and the angle BAC = $\frac{1}{2}$ (180°—45°) = 90°—$22\frac{1}{2}°$ = $67\frac{1}{2}°$; also angle CAO = 60°, and hence BAO = $67\frac{1}{2}°$ + 60° = $127\frac{1}{2}°$; also AO = AD = 2. Hence in the triangle BAO, we know two sides and the included angle, and from this the angle AOB may be computed, and should be equal to 13° 50′ nearly. But by the construction, in the triangle AMO, we know AM = $\frac{1}{2}$, AO = 2, and the angle MAO = 60°. Hence we may compute from the triangle MAO, in which also we know two sides, AM, AO, and the included angle MAO, the angle AOB, and we find it equal to 13° 54′ nearly. We find therefore that there is a difference of nearly 4′ between the angle at O as actually constructed and what it should be if the construction were correct. Hence the figure obtained would not be a perfect square, but a rectangle in which the base and altitude are nearly but not quite equal.

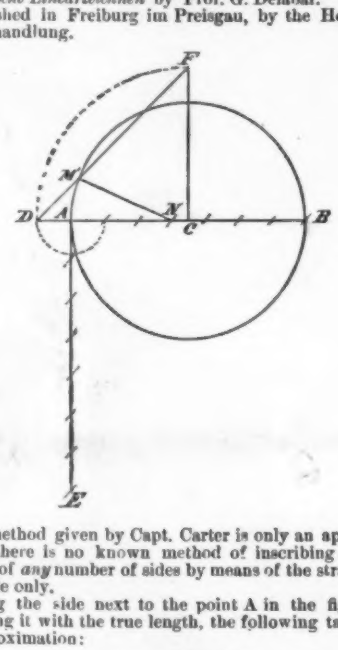
WALLER HOLLADAY,
Principal Private School, 26 West 43d Street.
New York, May 19, 1884.

THE POLYGON WITHIN A CIRCLE.

To the Editor of the Scientific American:

In the SUPPLEMENT of May 17, 1884, Capt. R. K. Carter gives a method of inscribing a regular polygon of any number of sides, and asks for the name of some published work in which it can be found.

He will find this with many other constructions in *Das geometrische Linearzeichnen* by Prof. G. Delabar. The book is published in Freiburg im Preisgau, by the Herder'sche Verlagshandlung.



The method given by Capt. Carter is only an approximation, as there is no known method of inscribing a regular polygon of *any* number of sides by means of the straight line and circle only.

Taking the side next to the point A in the figure, and comparing it with the true length, the following table gives the approximation:

No. sides.	Value of side R = 1.	Value of side by construction. R = 1.	Difference.
5	1 1756	1·1749	—0·0007
6..........	1·0000	1·0000	0 0000
7..........	0·8678	0·8692	+0·0014
8..........	0·7654	0·7684	+0·0030
9..........	0·6840	0·6886	+0·0046
10	0·6180	0·6240	+0·0060
11..........	0·5635	0·5705	+0·0070
12	0 5176	0·5256	+0·0080
13..........	0·4786	0·4874	+0·0088
14..........	0·4450	0·4544	+0·0094
15..........	0·4158	0·4256	+0·0098
16..........	0·3902	0·4004	+0·0102
17..........	0·3675	0·3780	+0·0105, etc.

It is called the Renaldian construction, from Renaldi, its inventor, who published it in 1668.

I beg leave to suggest another method with still more remarkable approximation:

Problem: To inscribe a regular polygon of any odd number of sides greater than five.

With any radius A C describe a circle. By means of any auxiliary line A E divide the diameter A B into any odd number of equal parts greater than five. On A B, produced, lay off A D, equal to one of the parts. On C F, at right angles to A B from the center C, lay off C F equal to C D. Join F D. Join M, the intersection of F D with the circle to N, the third division of A B. M N will be approximately one side of the regular heptagon, enneagon, etc.

The following table gives the approximation:

No. sides.	Value of side R = 1.	Value of side by construction.	Difference.
7	0·8678	0 8675	—0·0003
9..........	0·6840	0 6830	—0·0010
11..........	0·5635	0·5625	—0 0010
13..........	0·4786	0·4778	—0·0008
15..........	0·4158	0·4153	—0·0005
17..........	0.3675	0·3672	—0·0003
19..........	0·3292	0·3290	—0·0002
21..........	0·2981	0·2980	—0·0001
23..........	0·2723	0·2724	+0·0001, etc.

In applying this method to the heptagon, for example, it is best to use M N three times as a chord, then by known methods divide the remaining arc into four equal parts. This method is probably of German origin.

C. A. WALDO, *Prof. Math.*
Rose Polytechnic Inst., Terre Haute, May 17, 1884.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

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